Welcome to the 5th Annual GeoSymposium!

On behalf of the GeoSymposium Committee and the students of the Department of Geoscience, welcome to our event and thank you for joining us today.

I would like to extend an especially warm welcome to representatives from the many professional organizations, government agencies, and academic institutions joining us today. Many of you have traveled long distances to be here, and your time and genuine interest in our academic research as aspiring geoscientists is greatly valued.

As students, we greatly appreciate this opportunity to interact with you, the experienced, professional researchers, scientists, businesswomen and businessmen who have much to teach. I hope that today's research symposium will foster an exciting exchange of ideas, and that it will also forge many new partnerships.

Please enjoy our ten student oral and thirty-five poster presentations and two keynote speakers. Please join us for morning refreshments of coffee and Danish, courtesy of Barrick Gold, and later for a Texas-style BBQ in the courtyard, courtesy of ExxonMobil Corporation. Please join us for a post-symposium reception with appetizers, courtesy of Barrick Gold, and libations during a silent auction of rock, mineral and fossil specimens to raise funds for the next GeoSymposium. These events are scheduled to begin at 4 p.m. on the 2nd floor of the Lilly Fong Geoscience Building.

This year's field trip will be to Red Rock Canyon National Conservation Area, approximately 15 miles west of Las Vegas. The field trip will depart from the Lilly Fong Geoscience building (LFG) parking lot at 8:30am on Saturday, April 17th, and is expected to return to campus by 5:00pm. Lunch will be provided for all participants. Bring a camera to photograph the spectacular red sandstone peaks and walls. If you would like to participate in the field trip, but have not registered, please contact the registration desk.

Please enjoy yourself today and take time to interact with our talented students. Thank you for your time, your interest, and your continuing support of the UNLV GeoSymposium.

Best Regards,

Vicki Meyers
GeoSymposium Coordinator

Acknowledgments

Today's 5th Annual GeoSymposium is a result of volunteered time, labor, and helpful suggestions of many. An event of this magnitude would not be possible without the support of many hands and ideas of many minds. I want to acknowledge all the individuals, groups, companies, and corporations that deserve our gratitude and thanks for their involvement in today's special event.

Thank you to our guest speakers Bob Stewart, Gary Johnson, and Adolph Yonkee who gave generously of their time to travel to UNLV and to address us on their research, academic and Geoscience career opportunities. Please thank our sponsors listed on the following pages for their generosity, for without their support we would not have an event of this magnitude. Special thanks to ExxonMobil for sponsorship of the luncheon, Barrick Gold for the morning coffee and silent auction refreshments. Please give a round of applause and thanks to our own Department of Geoscience for printing and mailing expenditures.

I applaud our Department of Geoscience office staff, especially Maria Figueroa, office manager, and Liz Smith, accounts manager, for all their guidance, support, and assistance throughout the planning of this event. Thank you to student office workers Joy Martinez and Raniee Tiske who assisted with many little tasks that made my work load lighter.

I would like to thank UNLV Foundation staff and especially Craig Caskie, Director of Development for his sound advice and support. I greatly appreciate the discussions and recommendations of faculty advisor Andrew Hanson and Department Chair, Michael Wells. A special thanks to Becki Huntoon, my lifesaver, for all her extensive logistical and technical support with the website design and symposium mailings.

A special acknowledgement and thanks to a tremendous GeoSymposium planning committee. Each of you dedicated your time and effort to support the GeoSymposium and keep me sane through the past months. I am indebted to Laura Eaton, Jordan Armstrong, Pat Del Vecchio, Josh Bonde, Aubrey Shirk, James Thompson, Mike Giallorenzo, Corrine Griffing, Lora Griffin, and Amanda Williams; as well as many other students who volunteered their time and skills.

Thank you all for your encouragement and efforts to make this another successful GeoSymposium.

With much gratitude,

Vicki L. Meyers

Vicki Meyers
GeoSymposium Coordinator

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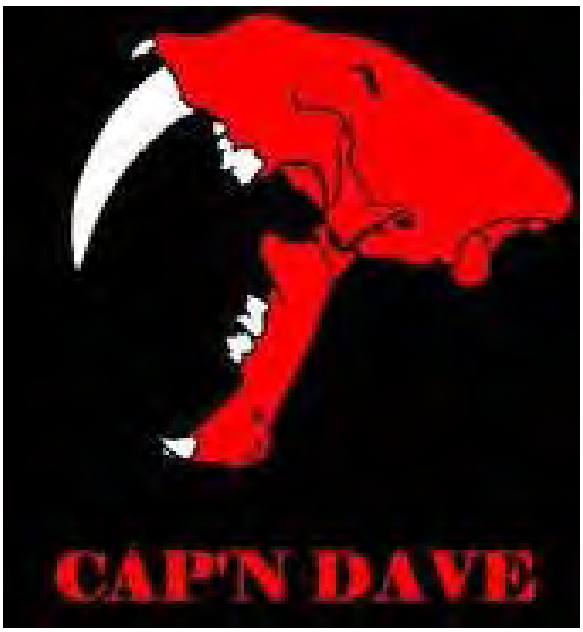

Nevada Isotope Geochronology Lab

Special Thanks to:

Jean Cline
Judy Costa
Paul Doback
David Einstein
Maria Figueroa
Wende Lestelle
Jim Mills

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Schedule of Events April 16-17th

Friday, April 16th, 2010

8:30am - Registration & Coffee

Opening Session

8:50 - Opening Remarks – Vicki Meyers & Michael Wells
9:00-9:30 - Morning Keynote Address – Bob Stewart, ExxonMobil

Session 1- Oral Presentations

9:30 - Laura Eaton (Structural Geology)
9:45 - Robert Henry (Sed/Strat/Paleoclimate)
10:00 - Jonathan Baker (Sed/Strat/Paleoclimate)
10:15 - Lora Griffin (Planetary Geology)
10:30 - Jason Cornell (Planetary Geology)
10:45 Break

Session 2 – Poster Presentations

11:00-12:00 - Poster Session

12:00 pm - Lunch (sponsored by ExxonMobil)

Session 3 – Oral Presentation and Poster Disscussion Session

1:00 - Alison Sloat (Paleoclimatology)
1:15 - Adam Zeiza (Sed/Strat/Paleoclimate)
1:30 - Lena Wright (Hydrogeology)
1:45 – Chris Adcock (Hydrology)
2:00 - Swapan Sahoo (Sed/Strat/Paleoclimate)
2:15-3:15 - Poster Discussion Session

Afternoon Sessions
3:15-3:45 - Keynote Address 2 – Gary Johnson, BLM Nevada Deputy State Director, Mineral Management
3:45 - Awards Ceremony & Closing Remarks
4:00 - Reception, Silent 2nd floor Lilly Fong Geoscience Building

Saturday, April 18th, 2010

8:30am - Field Trip: Red Rock Canyon National Conservation Area
UNLV Vehicles will leave from LFG parking lot.

GEOSYMPOSIUM COMMITTEE MEMBERS

Geosymposium Chair:
Vicki Meyers

Geosymposium Faculty Advisor:
Dr. Andrew Hanson

Abstracts with Programs:
Laura Eaton (chair), Corinne Griffing, Valerie Tu, Lora Griffin

Correspondence and Fundraising:
Aubrey Shirk (chair), Vicki Meyers

Facilities & Catering:
Aubrey Shirk (chair), Mandy Williams, Jeremy Koonce

Field Trip:
Josh Bonde (chair), Melanie Reed, Jason Norgan

Guest Speaker Search:
Michael Giallorenzo (chair)

Silent Auction:
James Thompson (chair), Julie Baumeister, Jonathan Baker

Symposium Set-up:
Pasquale Del Vecchio (chair), Lora Griffin, Joseph Asante

Web Page:
Jordan Armstrong (chair), Becki Huntoon

THANKS TO ALL OF OUR 2010 GEOSYMPOSIUM VOLUNTEERS!

DETERMINING THE LOCATION AND MOTION OF THE FRENCHMAN MOUNTAIN FAULT NEAR LAS VEGAS, NV

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Understanding the evolution of large-scale fault systems remains a challenge to geologists and is of critical importance in understanding the dynamics of larger plate tectonic interactions. The Frenchman Mountain fault (FMF) system within the Lake Mead Region of the Central Basin and Range serves as an example of such a fault system. Published tectonic models of southern Nevada ascribe different senses of fault motion to the FMF; some researchers classifying fault motion to solely normal (Langenheim et al., 2001) and others maintain the fault has experienced a combination of strike-slip and normal motion (Castor et al., 2000). Offset on the FMF has directly impacted how the basin adjacent to it has filled, thus documentation of provenance and basin evolution of basin fill as well as kinematic analysis and detailed geologic mapping allows for extrapolation of fault offset sense, magnitude, and timing. Stratigraphic, structural and kinematic relationships in the field imply normal fault motion indicated by: 1) the presence of vertical and sub-vertical slicken sides on fault surfaces, 2) relatively little lateral variation in stratigraphy within the basin indicating basin-fill being shed directly across the fault, supported by paleocurrent data, and 3) a lack of evidence that would suggest strike-slip motion. Based on fieldwork and subsequent analysis I have concluded that what is currently referred to as the FMF is mostly likely a series of normal faults that can be divided into three groups: the “main” fault group which is northwest-southeast trending and southwest dipping, a secondary set of faults trending nearly north-south and dipping to the west, and a third set conjugate to the secondary set which is trending northeast-southwest and dips to the east. The combination of the motion of the three fault sets comprises what is now referred to as the FMF, and is actually a series of faults as opposed to one major structure. In addition, I hypothesize that the main structure is located further to the southwest but is buried beneath younger sediments. Further research is needed to demonstrate the actual location of the FMF as well as the sense of motion of the fault.

PAIRED $\delta^{13}C_{CARB}$, $\delta^{13}C_{ORG}$, AND $\delta^{18}O$ STUDY OF LOWER MISSISSIPPIAN CARBONATES, SOUTHEASTERN NEVADA, USA

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A prominent positive carbonate carbon isotope ($\delta^{13}C_{carb}$) excursion of Early Mississippian age has been documented from numerous sites globally. This $\delta^{13}C_{carb}$ excursion has been interpreted as resulting from enhanced organic carbon burial that removed ^{13}C-depleted carbon from the ocean and the atmosphere. Anticipated outcomes from enhanced organic carbon burial would include a similar positive excursion in organic carbon isotopes ($\delta^{13}C_{org}$) and a global cooling event resulting from the enhanced organic carbon burial. These predictions, however, had not been tested sufficiently in existing documentations. This research has tested these predictions through an integrated study of carbonate and organic carbon, and oxygen isotopes of two Lower Mississippian sections in southeastern Nevada. Paired $\delta^{13}C_{org}$ and $\delta^{13}C_{carb}$ analyses and brachiopod oxygen isotope analysis across the positive $\delta^{13}C_{carb}$ excursion were conducted to test: (1) whether the $\delta^{13}C_{org}$ shows a similar positive excursion as has been documented in $\delta^{13}C_{carb}$, (2) whether seawater temperature changes across the $\delta^{13}C_{carb}$ excursion, as potentially recorded in oxygen isotopes of well preserved brachiopods, and (3) whether there is temperature-dependent carbonate and organic carbon isotope fractionation across the excursion. The first section near Alamo, Nevada the $\delta^{13}C_{carb}$ and $\delta^{13}C_{org}$ isotopic values are coupled; however, the covariation at the second section at Tungsten Gap, Nevada is debatable. Ongoing study will attempt to determine the cause of the differences between these two age correlative sections. The research has obtained a comprehensive dataset across a major paleoceanographic event, which sheds light on the interactions between paleoclimate changes, seawater surface temperature changes and isotope variations.

CARBON ISOTOPIC FRACTIONATION ACROSS A LATE CAMBRIAN CARBONATE PLATFORM: A REGIONAL RESPONSE TO THE SPICE EVENT AS RECORDED IN THE GREAT BASIN, WESTERN UNITED STATES

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Geochemical models have proposed that the late Cambrian was characterized by a greenhouse climate with high pCO_2. Furthermore, stable-isotope analyses within the Great Basin have documented a large carbon isotope ($\delta^{13}C_{carb}$) excursion, known as the Steptoean Positive Carbon Isotope Excursion (SPICE). This event has been documented globally, and is interpreted as having resulted from enhanced organic carbon burial. Unless the size of carbon reservoirs in the Cambrian ocean was significantly different from those of the Cenozoic, this forcing should have resulted in a comparable excursion in organic carbon ($\delta^{13}C_{org}$). It is also predicted that increased organic carbon burial would lower atmospheric CO_2. Organic carbon isotope data are presented here from Shingle Pass, Nevada and House Range, Utah. At Shingle Pass, $\delta^{13}C_{org}$ values record a positive excursion that roughly mirrors $\delta^{13}C_{carb}$ values at a similar magnitude, suggesting an oceanographic control on the carbon isotope trend. In the House Range section, although $\delta^{13}C_{org}$ values show a rough positive shift associated with $\delta^{13}C_{carb}$, the magnitude is smaller and values show minor shifts across the excursion. We interpret this to reflect a larger chemoautotrophic biomass contribution in the relatively deep water, semi-restricted basinal setting. The difference between organic and inorganic carbon isotope values ($\Delta^{13}C$) averages 27-28 per mil across both sections, but increases to 30 per mil at the peak of the excursion and falls to as low as 25 per mil immediately after the Sauk II/III sequence boundary. We interpret the parallel but reduced excursion in $\delta^{13}C_{org}$ values did reflect the production changes temporally across the SPICE event. During greenhouse conditions, $\Delta^{13}C$ is less sensitive to changes in atmospheric CO_2. Thus the increased organic fractionation during the SPICE event may have rather been due to diminished growth rates concomitant with sea level fall and a potential drop in atmospheric carbon dioxide.

INVERTED PALEOCHANNELS REVEAL A WATER-RICH LANDSCAPE DURING DEPOSITION OF THE MEDUSAE FOSSAE FORMATION LOWER MEMBER, MARS

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Elongate, sinuous ridges (SRs) with characteristics analogous to fluvial Earth processes are ubiquitous throughout the western portion of the Lower Member of the Medusae Fossae Formation (MFF), Mars. High-resolution images provided by the Mars Reconnaissance Orbiter (MRO) High Resolution Imaging Science Experiment (HiRISE) were analyzed to identify and characterize SRs within the MC23-NW map area which straddles the southern highlands – northern lowlands boundary near the Martian equator in the Elysium Planitia region. Six dominant SR morphologies were revealed by the HiRISE images analyzed including flat-crested, narrow-crested, round-crested, branching, non-branching, and multilevel SRs. Other common SR characteristics include 1) subparallel sinuous ridges that exhibit distributary branching down slope; 2) networks of flat-topped SRs that overprint multiple times, similar to braided or anastomosing streams; and 3) meandering stream and flood plain SR morphologies. Multiple mature SRs are concentrated around two large lobes and broad basin within the western portion of the MFF which contains an abundance of Lower Member deposits. The distributary nature of the ridges proximal to the lobes and basin, overprinting SRs, mature ridge sinuosity and parallel curving ridges similar to terrestrial scroll bars, strongly suggest that the ridges are inverted paleochannels exposed by differential erosion. Such well-developed meanders or scroll bars suggest extended fluvial flow, while overprinted anastomosing and distributary reach morphologies require more high-volume episodic flow. Although there is still much debate over the source and the nature of water on Mars, these images provide compelling evidence that both substantial aqueous extended channel flow and episodic channel flow were common throughout the formation of the Lower Member of the Medusae Fossae Formation.

PHOSPHATE MOBILITY IN A MARS ANALOG ENVIRONMENT

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The Mars Exploration Rover Spirit has recently documented the P-rich classes of rocks Watchtower and Wishstone in Gusev Crater, Mars [1]. Apatite, which contains phosphorous, is a quickly dissolving phase [2] and therefore likely to be chemically altered on Mars. Specifically, wavellite, a secondary Al-phosphate phase, has been detected in the Watch-tower class rocks of Gusev Crater by the mini-TES [3]. Strengite and ferristrunzite, Fe-phosphate phases, have also been detected by visible near infrared, thermal and Mössbauer spectroscopy in the P-rich Paso Robles soil of Gusev Crater [4].

Basalts from Craters of the Moon Lava Field (COM) in Southeastern Idaho have been proposed as a terrestrial analog to the P-rich Wishstone class rocks on Mars [5]. Phosphate forms different secondary products such as wavellite and strengite described above under varying conditions of pH, temperature, water:rock ratios and oxidation state so examination of apatite dissolution and secondary phosphate formation in this environment may help interpret the behavior of phosphate on Mars.

For this project samples were collected from the Kimama and Pronghorn lava flows where they are exposed at the surface and beneath the loess in order to characterize two different weathering environments. Thick sections were prepared by cutting with an isomet saw
using ethanol as the cutting fluid to avoid alteration of salts and were also polished in ethanol. The samples were than imaged by Scanning Electron Microscopy (SEM) with a backscattered electron detector and Electron Dispersive Spectroscopy (EDS) using a JSM5610 at the Electron Microanalysis and Imaging Laboratory (EMiL) at the University of Nevada, Las Vegas (UNLV).

Preliminary results indicate porosity formed due to mineral dissolution is apparent to ~250-300 μm in samples collected from surface flows in COM. The presence of Fe-phosphate phases in samples collected from the Pronghorn lava flows, and Al-phosphates collected from the Kimama lava flows is most likely not due to differences in elemental composition between the two flows, which contain similar amounts of Fe and Al [6] but may be due to natural variability or differences in the weathering environments.

References: [1] Gellert R. et al (2006) JGR, 111, E02S05 [2] Brantley S.L et al (2007) Kinetics of Water-Rock Interaction. [3] Ruff S.W. et al (2006) JGR, 111, E12S18. [4] Lane M.D. et al (2008) [5] Usui T. et al (2008) JGR, 113, E12S4 [6] Kuntz M.A. et al (1992) GSAM, pp. 227-266.

MODERN ISOTOPE CLIMATOLOGY OF ALASKA

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Stable isotopic values of modern surface waters are important indicators of the climatic controls on precipitation. An understanding of temporal and spatial variations of stable isotopes of oxygen ($\delta^{18}O$) and hydrogen (δD) in precipitation and surface waters in the northern latitudes of Alaska and Canada is necessary for interpretation of paleoclimate records from the region. To test the hypothesis that surface water $\delta^{18}O$ values are controlled temporally and spatially by moisture source and mean sample altitude, stream waters from glacial and non-glacial watersheds and precipitation from the Global Network for Isotopes in Precipitation database in Alaska and the Yukon Territories were analyzed for $\delta^{18}O$ and δD. Surface water $\delta^{18}O$ values range from -26.0 to -8.1‰, averaging -18.7‰. Surface water $\delta^{18}O$ values are controlled physiographically by latitude and mean sample altitude and climatically by distance from the coast. Several local surface water lines (LSWL) define physiographic regions of Alaska including Glacier Bay, the Alaska Range, the Chugach Mountains, and the White Mountains. The similarity of the surface water line (SWL) of $\delta D = 8 \times \delta^{18}O + 7.5$ to the Global Meteoric Water Line (GMWL) of $\delta D = 8 \times \delta^{18}O + 10$ shows surface water values are good proxies for the isotopic composition of precipitation in the northern latitudes. These data will be helpful in the interpretation of paleoclimate records from permafrost ice wedges in Central Alaska.

CARBONATE CYCLES AND STACKING PATTERNS OF THE FURONGIAN CARBONATE PLATFORM IN CENTRAL NEVADA AND WESTERN UTAH, WESTERN US: IMPLICATIONS FOR AUTOCYCLICITY UNDER SUPERGREENHOUSE CLIMATE

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Several mechanisms such as allocyclic, autocyclic and random facies models have been proposed to explain the formation of peritidal carbonate cycles and their temporal stacking patterns. However, there is still no solid consensus on the dominant mechanism(s) of cycles and stacking patterns formation for certain geological times (i.e., icehouse, greenhouse and supergreenhouse times). This 'cycle problem' especially occurs in the supergreenhouse Furongian time when changes in accommodation may not be dominantly controlled by eustatic sea-level fluctuations. Nevertheless, previous workers on the Furongian carbonate stratigraphy still invoke glacio-eustatic sea-level fluctuations as the main mechanism for cycles and cycle stacking patterns formation. This idea is very problematic for carbonate successions that developed during the Furongian time, when levels of atmospheric CO_2 were noticeably the highest (~4000-7000 ppm; Berner and Kothavala, 2001) compared to other Phanerozoic time intervals. Such high atmospheric CO_2 would have prevented the development of polar ice sheet, thus limiting and/or minimizing glacio-eustatic sea-level fluctuations. Five main sections and numerous laterally traceable short sections of the Furongian succession (ca. 502– 496 Ma) in central Nevada and western Utah were logged to investigate the facies associations, cycle types, cycle stacking patterns, and their possible controlling mechanisms. Peritidal to shallow subtidal cycles dominate in central Nevada, while deep subtidal and lagoonal cycles are the most common cycle types in western Utah. In each location, meter-scale cycles change in number, thickness and type in traceable outcrops, suggesting an autocyclic origin controlled by forced regression in response to changes in carbonate production rates. Decimeter-scale cycles are persistent in central Nevada and western Utah, respectively, but they are not correlatable between the two areas. This difference is likely controlled by syndepositional faults that created differential accommodation in the carbonate platform. Some regional discontinuities expressed by the combination of collapse breccia, desiccation cracks, paleosols and micro-karstifications are regionally persistent and potentially have significance at the basinal scale. The contrasting cycles and their stacking patterns in central Nevada and western Utah suggest that they are formed by interactions of post-rift thermal subsidence, local tectonic activities and carbonate production rates. This study is useful as an analogue for supergreenhouse carbonate reservoirs that are located below the surface (e.g., Ara group carbonates in the South Oman Salt Basin, Tommotsky group carbonates in the Siberian Platform) and also important to improve our understanding of the carbonate cyclo- and sequence stratigraphic concept under conditions of limited glacio-eustastic sea-level changes.

FATE AND TRANSPORT OF PHARMACEUTICALS IN AN IRRIGATED TURFGRASS SYSTEM

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Pharmaceuticals have recently gained attention as emerging contaminants in surface waters throughout the United States. Pharmaceuticals are taken by humans for a wide range of ailments. These compounds move through the body and enter the waste stream to local wastewater treatment plants where they are typically not removed even under tertiary treatment. After the wastewater treatment plant, the treated water is often discharged to rivers, lakes and oceans where they can potentially affect wildlife. An environmentally acceptable alternative to discharging such wastewaters directly to surface waters is the utilization of this water as an irrigation source for large turfgrass areas (golfcourses and parks). This study is designed to explore the fate and transport of several target pharmaceuticals after reuse water is applied as irrigation. A controlled lysimeter study is being conducted at the Center for Urban Horticulture and Water Conservation in North Las Vegas. To explore the mobility of pharmaceuticals under different soil-plant-irrigation conditions, lysimeters were constructed and filled with two different soil types (Sandy Loam or Loam), left bare or covered with turfgrass (hybrid bermudagrass/ryegrass) and then irrigated to impose two different leaching fractions (drainage volume/irrigation volume =0.25 or 0.05) A hydrologic balance is closed on each lysimeter on a weekly basis to estimate evapotranspiration by measuring soil water in storage (volumetric water content with depth) and irrigation and drainage volumes. Soil water in storage is used to estimate the unsaturated pore volume, which allows drainage volumes to be converted to pore volumes of water passing through the soil columns. Redox potential is measured on a weekly basis at depths of 15 and 105 cm to assess the aerobic or anaerobic status within the soil profile. Irrigation and drainage water is analyzed for electrical conductivity, cations, anions and 17 targeted pharmaceuticals. Conditions have been imposed for 16 months. Preliminary results will be discussed.

KINETIC STUDIES OF CHLORAPATITE DISSOLUTION AND IMPLICATIONS FOR MARS

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Water is a required environmental component for life as we currently understand it. As such, understanding the role of water in the environments of planets other than Earth gives us greater insight into the possibility of life, extant or extinct, on those planets.

Different dissolution/alteration rates of minerals and their derived mineral lifetimes can give us insight into the duration of water/rock interaction, and solution pH and composition. This understanding combined with present and future remote sensing and rover data from Mars may yield location, duration, pH, and compositional information of possible past water bodies on Mars. Mineral lifetimes for Mars conditions have been calculated for minerals such as olivine and the sulfate bearing mineral jarosite. Surface rock analyses from the Mars Exploration Rover (MER) Spirit indicate the surface is depleted in Ca and P, consistent with the dissolution of a phosphate bearing mineral. This is an indication that dissolution of phosphate-containing minerals may have occurred on Mars. The phosphate system is of particular interest because, in addition to being an indication of water presence, phosphorus is one of six main elements thought to be essential to biologic systems. Dissolution of phosphate minerals may have increased the availability of phosphorus to biologic or pre-biologic systems, if they existed on Mars.

While multiple studies have examined the dissolution rates of the phosphate-containing mineral fluorapatite, chlorapatite is a more common phosphate bearing mineral on Mars. Few dissolution rates exist for chlorapatite dissolution. Therefore, this research focuses on chlorapatite dissolution behavior in order to calculate dissolution rates and mineral lifetimes for this Mars relevant mineral, and for use in future quantitiave kinetic modeling. Our preliminary data show chlorapatite dissolution rates to increase with decreasing pH, similar to flourapatite. However, chlorapatite has generally higher dissolution rates.

PHOSPHORITE DEPOSITS AT THE DAWN OF ANIMAL LIFE

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At the Proterozoic-Phanerozoic transition (542 Mya) a causal occurrence of phosphorite deposition has been documented globally. It has been hypothesized that during this time interval hydrogen sulfide-rich waters moved upwards to the photic zone and acted as an extinction mechanism for the organisms. A similar phenomenon where hydrogen sulfide (H_2S) was released or persisted as a meta-stable euxinic (anoxic and sulfidic) zone, could have sustained throughout the terminal Proterozoic. This proposed mechanism for long term euxinia might have prevented eukaryotic life, but is still contentious.

The preservation and role of phosphorous (P) in the context of redox evolution and major environmental change is an intriguing geologic issue. P is one of the most important bio-limiting nutrients. Increase in P might increase primary productivity, which in turn will lead to enhanced production of organic carbon. This may lead to a deficiency of the oxygen budget in the water column, leading to anoxia and potentially leading to a euxinia. In the modern ocean where the water column is well-oxygenated, P is removed from seawater by adsorption onto oxides (Fe, Mn). During the Proterozoic this process of adsorption was much higher in the water column primarily due to extremely low sulfate concentrations. Conversely, today during anoxic conditions P is released from organic matter primarily due to the reaction of all available reactive iron with H_2S in the water column to produce iron-sulfides (FeS_2, pyrite). As a result, under increased sulfate concentration levels in the seawater, P is released from organic matter and delivered to the surface ocean either in the form of nutrient or as authigenic phosphate minerals which qualify for phosphorite deposit. Under such conditions, the photic zone could be highly toxic to the organisms due to the presence of H_2S, causing the primary productivity to shutdown, resulting in a surplus of P. Therefore, sulfur and P mediated redox evolution of the terminal Proterozoic ocean may have been very critical for the growth of animal life during the early Cambrian.

THE EFFECTS OF CONTACT METAMORPHISM ON HOST ROCKS FOR CARLIN-TYPE MINERALIZATION AT THE GETCHELL DEPOSIT, NEVADA

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The Getchell Carlin-type gold deposit in north central Nevada is located adjacent to the Cretaceous Osgood Stock and is locally hosted within the surrounding metamorphic aureole. The purpose of this study was to determine how calc-silicate alteration of potential host rocks caused by Mesozoic intrusions impacts subsequent Eocene age Carlin-type gold mineralization at the Getchell deposit. In this study ten drill holes were logged for the purpose of building two cross sections to explore the relationship between the contact metamorphic assemblage of the host rocks and the later mineralization.

There are two main host lithologies within the metamorphic aureole. The first is composed of tuffaceous mudstones and silty limestones. Contact metamorphism altered these limestones to a calc-silicate assemblage of wollastonite ± pyroxene ± pyrrhotite ± garnet and recrystallized calcite. The calc-silicate alteration of the silty limestones renders them poor host rocks. The other main sedimentary unit composed of siliceous carbonaceous mudstones inter-bedded with relatively pure limestone turbidites. Contact metamorphism resulted in the recrystallization of some of these limestone units, however they were not as readily altered to calc silicates, and locally remained potential host rocks for the ore fluids.

Mineralization is controlled by faults and dikes which acted as conduits for the ore-forming fluids. Ore grade mineralization is most common where these structures intersect units composed of siliceous carbonaceous mudstones inter-bedded with pure limestone turbidities, which were not altered to calc-silicates. Ore grade in these units is dominantly controlled by the abundance of limestone, with higher gold grades associated with the more dominantly limestone parts of the unit. The limestone was readily decalcified, silicified, and mineralized by the ore fluids, whereas mineralization in the siliceous carbonaceous mudstones is generally limited to fractures and veins occupied previously by calcite.

The second part of this study examined the distribution of iron-bearing carbonate proximal to the Osgood stock to determine if the stock was responsible for adding iron to the surrounding carbonates. Iron-bearing carbonates are proposed to be better hosts for Carlin mineralization, providing a source of iron for the ore fluids to sulfidize and precipitate gold bearing pyrite. This study revealed no systematic spatial relationship between distribution of ferroan carbonate and the stock. Rather, the distribution of ferroan carbonate is found to be largely controlled by lithology. The limestones with a silty component were found to be iron rich while pure limestones associated with the siliceous carbonaceous mudstones were iron poor.

DEFINING COMPONENTS OF INTERMOUNTAIN BASIN FLOW SYSTEMS USING HYDROGEOCHEMISTRY OF GROUNDWATER AND SURFACE WATER

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Determining groundwater sources, movement, and aquifer connection in the intermountain basins of the southwestern U.S.A remains challenging. Potentially, large uncertainties can occur when conceptualizing these components of groundwater flow systems. Uncertainties are attributed partly to geologic complexity of the Basin and Range Province. Rock formations with different hydraulic properties are disordered as a result of past tectonic thrusting and faulting.

Hydrochemistry of groundwater and surface water, in the lower Virgin River Basin and adjacent basins in Nevada, Arizona, and Utah, was used to study interbasin subsurface flow, intrabasin groundwater movement, and groundwater-surface water interaction in intermountain basins. Integrated data analysis techniques were applied to increase confidence in the interpretation of the hydrochemical data. In order to accomplish these objectives, first, spatial and temporal groundwater and surface water chemistry were compiled into a database. The discrete sites sampled were comprised of approximately160 groundwater and 24 surface water locations. Sources of the data were University of Nevada, Las Vegas/Virgin Valley Water District coordinated fieldwork, U.S. Geological Survey and U.S. Environmental Protection Agency databases, and unpublished governmental and master theses reports. Groundwater and surface water samples were classified into hydrochemical facies using cluster analysis, Discriminant function analysis, Principal Component Analysis, Geographic Information Systems, and fingerprint, compositional, and Piper diagrams. Our preliminary results supported the hypotheses that: interbasin subsurface water flows from the Clover Valley through the Clover Mountains to recharge the lower Virgin River Basin; the Virgin River recharges only the floodplain aquifer; the flood plain aquifer is separated from the rest of the aquifers; and the adjacent Escalante Desert Valley is another potential source of subsurface recharge. While the cluster analysis was robust in identifying hydrochemical facies, the other methods were effective in identifying hydraulic connectivity between the hydrochemical facies. The definition of the hydrochemical facies and interpretation of the groundwater flow system were enhanced by the methodology. The results show that, to sustainably manage and develop groundwater resource of the lower Virgin River Basin, water budget analysis and numerical modeling studies should consider interbasin groundwater flow and the interaction between the Virgin River and floodplain aquifer.

REWETTING RATES OF DESICCATED SOIL: EFFECTS OF TEMPERATURE, HETEROGENEITY, AND SOULTE CONCENTRATIONS

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The U.S. Department of Energy's Hanford Site located near Richland, Washington was a nuclear production complex located on the Columbia River. Millions of gallons of liquid wastes, including brines containing radionuclides were disposed into the subsurface. Because of the potential for contamination of the underlying Columbia aquifer, remediation in the area has become a priority. It was decided that soil desiccation could offer the most enticing advantages. However this technique has not yet been used for contaminant remediation. Initial testing has shown that injecting warm, dry air into soil removes nearly all moisture from the test medium, eliminating the mechanism for downward contaminant migration. Although this is encouraging, virtually no research has been done on the rewetting processes of treated soils. Our project aims to gain a better understanding of the rewetting processes of desiccated soil, including rates in homogeneous and heterogeneous soils, and in soil containing elevated salt concentrations. We will use laboratory experiments in an effort to answer our hypotheses. Acrylic tubes will be packed with glass bead, quartz sand, and actual Hanford sand to represent both homogeneous and heterogeneous systems. These tubes will be lined with sensors that will monitor temperature and relative humidity as a function of time and distance from inlet, and water mass flux into the column. These factors will allow us to calculate the diffusion coefficients for each soil system we test. Our results will help decided if soil desiccation is efficient, and thus an economically viable contaminant remediation technology.

UNSATURATED FLOW IN DUAL-POROSITY GRANULAR MEDIA

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A geological medium made up of coarse porous rock fragments contains two types of pores; small pores within individual fragments and large pores between the fragments. We use the term "dual-porosity granular media" to describe such media, which are found in a number of man-made systems, including: heap leach piles, mine waste, backfills, rock drains, and engineered capillary barrier systems. Unsaturated fluid flow in a dual-porosity granular medium will have two main flow elements; matrix flow (through individual fragments), and film flow on the fragment surfaces. The matrix flow is controlled by capillary forces, and is likely to be several orders of magnitude slower than gravity-driven film flow. The combination of these two mechanisms is expected to produce complicated flow regimes.

A meter-scale column experiment was constructed to investigate the spatial and temporal structure of unsaturated flow in dual-porosity granular media. A test column (30 cm inside diameter, 100 cm tall) was filled with crushed porous quartzite (~1.5 - 3 cm diameter) to produce a medium with two distinct pore sizes. Water was supplied through a point source to the top of the column at a steady rate (8.0 ml/minute) and exited through nine equal-area basins at the bottom of the column. Inflow, outflow from each of the nine basins, temperature (ambient and inside the column), humidity (ambient and inside the column) and barometric pressure were measured at 2 minute intervals.

Analysis of data collected from two experimental trials (10 and 40 days long) provided several important results. Outflow from the column started ~3.5 hours after inflow began, then increased rapidly and stabilized at slightly less than the inflow rate after ~16 hours. We observed measurable outflows through all nine sections at the bottom of the column; however the contribution to the total outflow from each section varied from approximately 5% to 20%. This observation implies that fluid flow occurred in spatially discrete pathways, which were non-uniformly distributed within the domain. Outflow from each section was significantly variable over time. Simultaneous changes of outflow rates through different sections occurred both gradually and abruptly; however, total outflow rate remained nearly constant. These observations could be explained by spontaneous switching between multiple discrete flow paths within the domain. Results suggest that accurate predictions of flow and solute transport through dual-porosity granular media will be difficult, as will estimating extraction efficiency in heap leach piles.

TEMPERATURE PROPAGATION AND WETTING FRONT EVALUATION AT THE BOULDER CITY, NEVADA, LYSIMETER FACILITY

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Temperature and soil water content data was evaluated for three weighing lysimeters located in Boulder City, NV. Profiles of water and energy loss and gain help to improve the understanding of soil physical processes in arid regions. One year (2009) of data was collected from an array of different technologies to measure temperature (thermistors, thermocouples, and fiber-optic Distributed Temperature Sensing) and water content (time domain reflectometry, dual-probe and triple-probe heat-pulse sensors, and heat dissipation sensors). To determine the accuracy and precision of the instruments and experimental approach, a statistical evaluation and intercomparison of the individual lysimeters was conducted, including mean, variance, and linear regression. In addition, temperature data from lysimeter soil were compared to ambient air temperature data within the lysimeter tunnel to determine if radial heating occurs from the metal infrastructure, and to natural soil instrumented with thermocouples at the same depths as the lysimeter. A statistical evaluation of temperature and soil water content data will provide a vital foundation for future experiments, as it demonstrates that the lysimeters provide environmentally representative data, allowing us to extrapolate the data to soils outside of the lysimeters themselves. We hypothesize that there is no significant difference of temperature and soil moisture between each lysimeter and lysimeters provide an accurate means of measuring heat and water transport similar to native soil. Future potential experiments in the lysimeters include analysis of plant rooting behavior of native desert shrubs and analysis of how cyclic rise and fall of a shallow water table affects evapotranspiration (ET) processes, which are important to both the surface energy balance and hydrologic cycle, particularly in arid and semi-arid regions where ET often dominates water loss from ground surface. Closer inspection and better understanding of these processes are crucial for closing the water budget. The knowledge gained at this facility will be ported to a more complex field site in Spring and Snake Valleys, NV, where the water table is known to be shallow (<10 m) and available for phreatophytic shrubs.

FOG HARVESTING AS GROUNDWATER RECHARGE

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In response to the infiltration of salt water into the groundwater table in the Cape Verde Islands the experimental use of fog harvesting as a source of groundwater recharge will be explored. Construction of fog harvesting nets will be undertaken with local community support and cooperation; providing a means for research as well as a source of potable water for the participating communities.

OIL-SOURCE ROCK CORRELATION IN RAILROAD VALLEY, NYE COUNTY, NEVADA

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The first discovery of oil in Nevada occurred at Eagle Spring oil field in 1954 in Railroad Valley, Nevada. Since then the basin has became the major oil-producing province in the Basin and Range region, with approximately 44 million barrels of oil produced to date.

However, the source of oil in this prolific oil province remains problematic. Geochemical analyses conducted by several different researchers led to different conclusions. Three different schools of thought emerged: one postulated that the Tertiary Sheep Pass Fm member B serves as a main source rock (Picard, 1960), one favored generation from the Mississippian Chainman Shale (Claypool et al. 1979 and Poole et al. 1983) while the other suggested the oil had affinities for both Sheep Pass Fm member B and Chainman Shale (Bortz and Murray, 1979; Duey, 1979; French, 1983; Poole and Claypool, 1984; Conlan, 1995). These differences were mainly due to the use of different and small sets of data as well as a limited number of biomarkers analyses.

I hypothesize that three different oil families exists in this basin. Oils are derived from the Mississippian Chainman Shale, the Tertiary Sheep Pass Fm member B, or a mixture of those two source rocks. The structural complexity in this valley as well as the different thermal histories of potential source rocks led to this variation.

This research will produce the most comprehensive geochemical dataset of crude oil and presumptive source rocks in order to establish oil-oil and oil-source rock correlations. The resulting comprehensive understanding of active source rock(s)- will help constrain oil generation models and will help define migration pathways and trapping mechanisms. Furthermore, the results will significantly influence future exploration strategies in the Basin and Range province.

BURIAL AND UPLIFT HISTORY OF MISSISSIPPIAN STRATA IN EAST-CENTRAL NEVADA IN THE LATE PALEOZOIC

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East-central Nevada is known for its petroleum resources, and Railroad Valley (RRV) is the major oil field in the area. Although the Mississippian Chainman Shale is the most important source rocks for RRV, very few studies have been conducted to constrain the burial history of Mississippian strata. One previous study indicates that there was significant burial of Mississippian strata followed by an uplift event in the Permian that resulted in uplift and major erosion of Paleozoic sediments in the Egan Range adjacent to Railroad Valley. The data indicate that this event occurred in the Late Permian. The hypothesis to be tested in my study is that Permian uplift documented in the Egan Range also occurred in Railroad Valley and other areas of east-central Nevada. This study requires fieldwork for data and sample collection. Vitrinite reflectance analyses (Ro) will be completed in order to determine the thermal maturity and burial history of the Chainman Shale. Paired (U-Th)/He analyses will be conducted on the Scotty Wash Sandstone samples, a clastic member of the upper Chainman Shale. The (U-Th)/He data will be used to evaluate the uplift history of the Paleozoic sequence. In addition to constraining the thermal maturity of the Chainman Shale and the Late Paleozoic uplift event in east-central Nevada, this study will contribute to a better understanding of the maturation history of the source rock in RRV and the Late Paleozoic regional uplift.

Evaluation of potential source rocks in northern Nye County: Implications for hydrocarbon exploration.

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All commercially produced oil from the Eastern Great Basin has come from Railroad Valley or Pine Valley, totaling approximately 50 million barrels of oil. Confirmed source rocks are the Mississippian Chainman Shale and Maastrichtian to Paleocene-Member B of the Sheep Pass Formation, but there are a number of other potential source rocks in northern Nye County. These include the Newark Canyon Formation, the Kanosh Shale, the Pilot Shale, the Slaven Formation, the Vinini Formation, the Woodruff Formation, and the Ely Limestone. Very little work has been done towards investigating the richness and thermal maturity of these potential source rocks, and exploration in the basins west of Railroad Valley has often amounted to no more than one or two exploratory wells drilled per basin. This thesis will assess these potential source rocks in terms of their biomarker composition, thermal maturity, and organic richness.

IS THE AMBOSELI BASIN OF EAST AFRICA A MODERN ANALOGUE FOR THE PLIOCENE PANACA AND GLENNS FERRY FORMATIONS OF WESTERN NORTH AMERICA?

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The Pliocene was a significant time in North America for climatic fluctuations and intercontinental dispersal of mammals. To better understand these changes, we are studying the depositional environments and community structure of two Pliocene (Blancan Land Mammal Age) terrestrial basins of western North America: the Panaca Formation of Lincoln County, Nevada, and the Glenns Ferry Formation exposed in Hagerman Fossil Beds National Monument of southern Idaho. We propose that the Amboseli Basin of Kenya is roughly comparable to the two Pliocene inland basins of western North America, in terms of depositional environments and community structure. Like the Amboseli Basin, the Panaca and Hagerman deposits are dominated by fluvial and lacustrine sediments, and they probably experienced a distinct wet-and-dry seasonality. The Amboseli Basin is in the rain shadow of Mt. Kilimanjaro, and its rainfall averages about 30 cm (11.8 inches) per year. This is probably comparable to the Pliocene rainfall at Hagerman (in the rain shadow of the Cascades) and probably wetter than the Panaca Basin in the Pliocene.

Not surprisingly, the mammalian fauna of the Amboseli Basin has a very high species diversity with a total of seventy-one species. In comparison, fifty-nine mammal species have been recorded from Hagerman Fossil Beds, and thirty-five from the Panaca Formation. As recorded in the table below, in spite of these differences in species richness, the relative abundance of various mammalian morphologies within each trophic level is similar in the three areas.

	Amboseli Basin	Panaca Fm.	Hagerman
Small mammals	70.4%	74.3%	71.6%
Large herbivores	18.3%	20%	17.8%
Large carnivores	11.3%	5.7%	10.7%

We will use the species richness and community structure of the Amboseli Basin for the purpose of analyzing and comparing the diversity and community structure of the Pliocene inland basins of western North America.

CARBONATE CYCLES AND THEIR CONTROLLING MECHANISM DURING FURONGIAN GREENHOUSE TIME: AN EXAMPLE FROM THE BIG HORSE MEMBER OF THE ORR FORMATION IN WESTERN UTAH

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Carbonate depositional cycles and sequences have been proposed to be formed by glacioeustastic sea-level changes. This mechanism would be questionable during times of high atmospheric CO_2 and negligible continental ice sheets such as the super greenhouse time in the Furongian (late Cambrian), during which limited glacioeustastic sea-level changes would be expected. A detailed sedimentological study of the Furongian Orr Formation in the Little Horse Canyon, western Utah, implies that meter-scale cycles display large lateral and temporal variability in a 1.2 km^2 area.

The Big Horse Member of the Orr Formation mainly consists of mudstone, siltstone, onciodal-peloidal wackestone, oolitic and inraclastic grainstone/packstone, microbial laminaes, and thrombolites that were deposited from shallow subtidal to supertidal environments. Meter-scale cycles are expressed by shallowing-upward trends with subtidal mudstone and/or siltstone at the base, followed by supratidal microbial laminaes and thrombolite heads with desiccation cracks and karstic breccias at the top. Among the seven closely-spaced sections with a traceable marker bed, the cycle numbers vary. The cycle thickness change from 2 m to 20s m, and moreover the microbial boundstone can reach until 30s m of vertical stack. Individual cycles are found to change within a few hundreds of meters to non-cyclic interval or, in some cases, several cycles merge into a single cycle within short distances (100-200 m). However, a stratigraphic discontinuity marked by intensive subaerial exposure was traceable among sections.

These features suggest that meter-scale cycles of the Big Horse Member were mainly formed by autocyclic process through interactions between local carbonate production rates and tectonic subsidence. Forced regression during times of high carbonate production formed the laterally persistent discontinuities, but their duration may have varied, with significant lag time recorded in some sections.

EFFECTS OF CLIMATE ON WEATHERING RATES AND WEATHERING PRODUCTS OF OLIVINE

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Chemical weathering is an important process that is a critical component in soil formation, global carbon cycles, and controlling the chemistry of soils and waters. With growing concerns due to global climate change, it is important to understand the dissolution of ultramafic minerals because they consume a significant amount of carbon dioxide during the weathering process (Dessert et al., 2003). Therefore, quantifying the field dissolution rates of the ultramafic mineral olivine may prove useful in future studies that involve modeling of rock-water interactions in the context of climate studies and carbon sequestration.

The goal of this study is to determine the effects of climate on the dissolution rates and weathering products of olivine in natural environments. Despite an extensive literature of laboratory olivine dissolution experiments, few studies have examined olivine dissolution rates in the field (Schnoor, 1990). Using surface exposure ages from cosmogenic nuclides and dates of deglaciation, representative dissolution rates of olivine will be calculated for two field sites with differing climates (Black Rock Flow, Nevada and Klamath Mountains, California). It is hypothesized that the sites will have significantly different dissolution rates and weathering products due to differing climatic conditions.

Olivine xenoliths from the arid Nevada site and dunite soil cores from the moderate California site will be analyzed using two different techniques. Scanning electron microscopy (SEM) will be used to identify and measure weathering pits on olivine xenolith surfaces. The dissolution rate can be calculated using the volume of weathered material, measured from weathering pits, and the age of the basalt exposure (Gordon and Brady, 2002). Chemical and mineralogical depletion profiles from the dunite soil cores will be determined using X-ray fluorescence (XRF) and X-ray diffraction (XRD). Soil depletion profiles normalized to the parent material, unaltered dunite, are then used to obtain a weathering rate (White, 2002).

The dissolution rates and weathering products at each study location will be compared. If the rate from the Nevada site is significantly different from the rate calculated from the Klamath Mountains, California, it can be concluded that climate is affecting the rate of olivine dissolution.

OLIVINE DEFORMATION AND ELASTIC PLASTIC SELF CONSISTENT MODELING

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Olivine is the most common mineral in the upper-mantle and weakest mineral in the upper-mantle. Thus the strength of olivine controls the rheology of the earth's upper-mantle. The stress state of olivine in the upper mantle has important implications for mantle flow, mountain building, and post glacial rebound. The flow strength of deformed olivine polycrystals has been estimated under the assumption of a homogeneous state of stress (Chen et al., 2004). X-ray synchrotron diffraction experiments have implied that this assumption is not always valid (Li et al., 2004). Elastic Plastic Self Consistent (EPSC) modeling offers an approach to estimating the flow strength of olivine that does not assume a homogeneous stress state. EPSC modeling is based on the Eshelby inclusion principle and is an iterative approach. Input for EPSC model simulations includes slip systems and the critical resolved shear stress for slip systems. Strain output from the EPSC model has been compared to strain measurements from lattice planes in olivine polycrystals that have been deformed during synchrotron XRD experiments. The EPSC model predicts well with lattice plane strain measurements in the elastic realm of deformation but diverges from lattice plane measurements in the plastic realm. Kinking is a deformation mechanism which can be incorporated into the EPSC model and could potentially improve the accuracy of the model's output relative to lattice plane diffraction measurements.

PROVENANCE OF THE MIOCENE-PLIOCENE MUDDY CREEK FORMATION NEAR OVERTON, NEVADA

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We are currently studying the Muddy Creek Formation (MCF) near the Overton arm of Lake Mead, NV to understand several important geologic questions. In particular, 1) documentation of the MCF stratigraphy is needed in order to constrain models pertaining to the establishment of the modern Colorado River drainage; 2) the age of the Mormon Mesa geomorphic surface which is potentially one of the oldest geomorphic surfaces in the world, occurs within the map area and is developed on a stratigraphic unit whose age is contested; and 3) refinement of Miocene-recent fluvial and erosional processes in the Mormon Basin.

Initial mapping of the Overton SE 7.5-minute quadrangle has produced data that help constrain the Miocene-Pliocene (~10-4 Ma) provenance and paleodrainage systems of the southern Virgin River. We also refine the Quaternary history of the upper section of the MCF. At least four base-level changes have occurred since the deposition of the MCF and remnant alluvial fans show that the modern Virgin River's channel has shifted ~2.5 km east to its current location since the middle Pleistocene. Future mapping in the area aims to gain age control for the upper MCF, map structures that may be responsible for the river channel's movement, and measure stratigraphic sections to further constrain the provenance of, and lateral variation within the MCF.

THE PROPAGATION OF UNCERTAINTY THROUGH STRESS, STRAIN RATE, AND VISCOSITY FLOW LAWS OF A LOWER CRUSTAL SHEAR ZONE

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A fundamental goal of structural geology is to quantify the strength of rocks at various crustal depths. Existing studies apply experimental flow laws with measures of grain size and temperature to quantify values of stress, strain rate, and viscosity in exhumed shear zones. In these types of studies, however, deformation temperatures are not directly measured and uncertainties in measured and experimental parameters are not considered when comparing rheologic properties in given a shear zone.

This study combines measurements of grain size and temperature with experimental flow laws to calculate the stress and strain rate of lower crustal Paleozoic rocks in the Duraznos shear zone located in northwest Argentina. Optical microscopy was used to measure grain size in quartz rich mylonites that underwent grain boundary migration recrystallization. Quartz c-axes were measured by electron back-scattered diffraction and used to calculate temperature for each sample.

Top-to-the-west thrusting juxtaposed rocks of varying lithology, grain size, temperature, and viscosity. Grain size ranges from 149 um in the footwall, 30 – 42 um in the shear zone, and 228 um in the hanging wall. Temperature ranges from 508° to 602° C. Strain rate varies from 10^{-16} to 10^{-14} s^{-1} and viscosity varies from 10^{21} to 10^{23} Pa/s across the shear zone.

We propagated errors from measurements of grain size and temperature as well as experimentally determined flow low parameters to calculations in differential stress, strain rate, and viscosity using the basic equation for error propagation. The relative errors on stress are on the order of 20 to 40%. The largest contribution to absolute uncertainty comes from the uncertainty of grain size estimation. Strain rate and viscosity estimates have absolute errors of ± 1.5 orders of magnitude. When considering experimental values activation energy is the largest contributor to uncertainty. When only considering the grain size and temperature, temperature is that largest contributor in fine grained rocks, while stress and temperature contribute equally to the uncertainty in coarse grained rocks. The largest contributor to absolute uncertainty in viscosity is strain rate.

Experimental petrologists should focus future work on better constraining the activation energy for dynamic recystallization. This study shows there is sizable uncertainty when quantifying stress and strain rate with flow laws that are rarely calculated in published studies.

PALEOSEISMICITY OF THE STATELINE FAULT, SOUTHERN NEVADA

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The Stateline Fault system (SFS) is a Quaternary NW-striking dextral fault system that lies along the SW Nevada and SE California border. The Stateline fault slip rate, lateral continuity, and the inclusion of other proximal parallel to sub-parallel fault systems are disputed. The inclusion of the Pahrump, Amargosa, and Mesquite faults as segments of one large interconnected SFS by Guest et al. (2007) implies the potential for a large magnitude earthquake using the Wells and Coppersmith (1994) theory of earthquake magnitude increasing with surface rupture length analysis. Supporting this concern is a discrepancy in the rate of slip between the observed geodetic rate of 1.13 mm/yr (Bennett, 2003) and the historical averaged slip rate since mid-Miocene of 2.3 ± 0.35 mm/yr (Guest et al., 2007). This discrepancy may indicate regional fault strain accumulation before an earthquake.

An earthquake occurring on the SFS would pose a major threat to the 2.5 million people in Pahrump and Las Vegas, Nevada; and the major gas and power corridors that pass through the fault zone. This risk can be mitigated through a better understanding of the SFS tectonic history, magnitudes of previous earthquakes, location of previous earthquake events, and lateral extent of the fault system. The data can then be applied to the future development of infrastructure and building codes.

In addition to the earthquake assessment, the SFS is scientifically interesting because it lies inside the Walker Lane and/or the Eastern California Shear Zone and needs to be better categorized as to which it belongs. Although the SFS is mostly a dextral fault, a change in the dip-slip amount is observed along strike through the Pahrump segment crossing from the southern Pahrump basin northward into Stewart Valley. This change of slip has possible implications for the regional tectonics and fault segmentation.
I propose to test the following four hypotheses. (1) The SFS is an active Quaternary fault that poses a hazard to urban areas and radiocarbon dates of sedimentary deposits associated with earthquakes will provide ages of recent events. (2) The change in the amount of dip-slip component along the SFS relates to changes in fault geometry. (3) The fault is geometrically complex with multiple strands accommodating fault motion. (4) The SFS is tectonically related to other faults through strain partioning or slip transfer.

COOLING HISTORY OF THE WHEELER PASS THRUST SHEET OF THE SOUTHERN SEVIER FOLD-THRUST BELT USING (U-TH)/HE THERMOCHRONOLOGY.

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The Wheeler Pass thrust in the Spring Mountains of southern Nevada accommodated a significant amount of shortening in the southern Sevier fold-thrust belt. Despite its strain significance, timing of thrusting remains uncertain. Movement has been assigned to the latest Jurassic (~147 to 142 Ma) by tentative correlation with the Pachalka thrust in the Clark Mountains thrust complex, eastern California. Alternatively, foredeep deposits from the eastern Spring Mountains containing clasts derived from the Wheeler Pass thrust sheet, as well as preliminary fission track data, strongly suggest erosional exhumation at ~100 Ma. These conflicting hypotheses will be tested by obtaining a zircon (U-Th)/He thermochronology profile across the hanging wall of the Wheeler Pass thrust. Resolution of the age of the Wheeler Pass thrust will allow correlations to other thrust faults in the Clark Mountains, Mesquite Mountains, and Panamint Range to be tested, with implications for both the timing of shortening in the Sevier fold-thrust belt and estimates of Cenozoic extension in the Death Valley region.

LATE PALEOZOIC, MESOZOIC, AND CENOZOIC SUPERIMPOSED DEFORMATIONS, TIMPAHUTE RANGE, NEVADA

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Major deformational events in south-central Nevada, U.S.A., include the Antler, Sonoma, and Sevier orogenies, and Cenozoic extension. Between the Devonian-Mississippian Antler and the Permian-Triassic Sonoma orogenies, south-central Nevada appears to have remained tectonically inactive. However, Pennsylvanian or Permian age deformation is documented to the south near Death Valley and to the north. Late Jurassic to early Cenozoic deformation occurred during the Sevier orogeny in a hinterland branch of the Central Nevada thrust belt (CNTB). The N-S trending CNTB is exposed in at least nine ranges, including the Timpahute Range, in which the study area is located. Cenozoic extension fragmented the earlier thrust belts and rhyolitic to dacitic calderas formed.

In the Timpahute Range, preliminary data show that east tilting of the Tempiute Ridge block, which is bound on the east by the Schofield Pass fault (SPF), occurred prior to intrusion of the Cretaceous Lincoln stock, which paleomagnetic data show is not tilted. Therefore, if the SPF tilted the block, it must have been active prior to stock emplacement. This relation may suggest deformation in the area which pre-dates the Sevier orogeny and the CNTB, possibly during a lesser known Pennsylvanian-Permian deformation.

The purpose here is to evaluate the origin of structures that do not appear to fit with previously recognized deformation of the region (e.g., SPF) and test the hypothesis that movement along the SPF occurred prior to CNTB deformation. It is important to identify this event due to the potential changes in regional tectonic history. To accomplish the objectives, the proposed area was mapped at 1:12,000 scale. Analyses include schematic cross sections, stereographs, and dating including biostratigraphic and ion microprobe zircon analysis.

The new mapping shows five fault sets: NE-striking faults, E-W-striking normal faults, NW-striking normal faults, NW-striking thrust faults, and the N-striking SPF zone, which reaches up to 1 km wide. New mapping also shows the SPF is a non-planar, segmented fault zone which dips steeply east and places Cambrian over Mississippian to Pennsylvanian units. The main fault splays to the north and south. Each branch is accompanied by parallel folds in the thin bedded late Paleozoic units, particularly in the Pennsylvanian Ely Limestone. Major folds trend NW, which may prove to be related to shortening along the SPF zone. The SPF and related structures show shortening along this fault which was previously documented as either thrust or strike-slip (Tschanz and Pampeyan, 1970).

TECTONIC DEVELOPMENT IN THE WHITE PINE RANGE AND EAST-CENTRAL NEVADA

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The Phanerozoic tectonic evolution of western North America consists of multiple contractional and extensional events that are recorded in Nevada. Rocks in the White Pine Range, of east-central Nevada, record the deformational events that occurred in the late Paleozoic, Mesozoic and Cenozoic. Deformation in the late Paleozoic, between the Antler and Sonoma orogenies, is documented in several locations throughout central Nevada as an angular unconformity. The Mesozoic contractile structures in the White Pine Range are known as the Illipah fold and thrust belt, which is a part of the central Nevada thrust belt. The youngest structures are extensional faults that overprint the contractional structures and were active in the Cenozoic. Documenting the structural style of these deformations contributes to understanding the tectonic evolution of western North America. The questions to be addressed include: (1) do the late Paleozoic, Pennsylvanian-Permian, rocks record a previously unrecognized deformation, (2) does the Illipah fold and thrust belt record east to west shortening, and (3) is the Cenozoic extension dominated by low-angle normal faulting?

Detailed geologic mapping at a scale of 1:12,000 in the northern White Pine Range and various structural analyses were performed to address these questions. Stereographic projections were used to determine structural orientations and kinematics. Retrodeformable and deformed state cross-sections are being constructed to interpret structural geometries, calculate amounts of contraction and extension, and to construct a temporal stepwise structural development. Thin-sections of late Paleozoic rocks and Cenozoic volcanic rocks are being used to establish a better stratigraphy and biostratigraphic dating of fusilinids will be used to define the age of unconformities exposed in the field area.

The initial results (1) further constrain the tectonic style of the central Nevada thrust belt to be mainly large folds, (2) define a better stratigraphy for Pennsylvanian and Cenozoic volcanic rocks by subdivision of existing units, and (3) provide a geologic map and insight for future production and exploration of hydrocarbons in Railroad Valley. Future interpretations and dating of fusilinid samples is necessary and will contribute to the understanding of the proposed deformation event in Pennsylvanian-Permian time.

WATER WATER ANYWHERE?

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The City of Las Vegas and surrounding comminutes are dependent on Lake Mead and the managed Colorado River system for 85% of their water needs. Other communities along the upper and lower Colorado River system are also heavily dependent on the river. Despite the recent economic down turn, the population of Clark County is expected to grow by as much as 52% over the next two decades. The Clark County 2005 Hazard Mitigation Plan does not directly address lack of available water as a possible hazard, and has evaluated "water system failure" as a low priority hazard not requiring further evaluation.

Our goal in this research is to determine if continued heavy dependence on the Colorado River system as a water resource for southern Nevada is viable or presents a hazard. We attempt to evaluate the expected water resource needs as southern Nevada's population continues to grow and if meeting those additional resource needs solely from the Colorado River is possible. Several confounding factors are addressed including Upper Colorado River population growth, redistribution of water resources away from the Imperial Valley, extreme conservation measures, and predicted release requirements to downstream communities.

FLOOD PROTECTION IN SOUTHERN NEVADA

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Through the use of geographic information systems (GIS), we are able to model the effects of various disasters should they occur in Southern Nevada. This project will focus on potential flood damage produced by a 100 year storm event through the use of various GIS datasets. This project will also compare the potential damage to areas located within a current flood zone to the potential damage of areas that have been removed from a flood zone due to the implementation of flood control facilities. Furthermore, the savings of the potential damage to these areas can be compared to the cost of implementing these facilities.

A collection of various GIS data files will be obtained to determine the areas that will be affected by flooding and the potential damage that would occur. In order to locate areas affected by flooding, a 100 year flood zone dataset that is provided by the Clark County Regional Flood Control District (CCRFCD) will be used. The 100-year map will be used to compare areas removed from a flood zone due to implementation of a flood control facility, created through letters of map removal (LOMR), which denotes areas that are no longer in a flood zone as they are now protected by a flood control facility.

In order to compare these two data sets we will need a third dataset which displays the affected population or the potential damage. Population data may come from census datasets which will provide a population within each census tract. The intersection of flood zone areas and census tract will give a rough estimate of the population affected by a 100 year flood. This can be compared to populations located within areas removed from the flood zone as well. An alternative approach would be to use assessed parcel values obtained from Clark County Assessor's Office. This would allow for a direct evaluation of the potential damage costs of the areas within the flood zones. These total damage costs can be compared with the potential damage of areas that have been removed from flood zones. In addition, CCRFCD also provides a dataset of completed regional flood control facilities and their construction costs. This dataset can be used to justify the cost of implementing these facilities by comparing it to the savings of potential damage to areas that are now protected by these facilities.

TO PERFORM RISK ANALYSIS AT CLARK COUNTY DUE TO FLOOD AND EARTHQUAKE

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The project area to be considered is one of the fastest growing counties in Nevada, Clark County, with a population of around 1,865,746 out of total population of 2,600,167 in Nevada. The major objective of this project is to perform the risk analysis in Clark County due to the combine effects of earthquake and flood. The datasets required for this purpose are available from Clark County, including the fault zones, census data for 2000 and soil type. Flood plain Datasets are available from Clark County Regional Flood Control District. The flood zones contributed by 100 year flood will be considered, and the required layers are delineated from the obtained datasets for the risk analysis. Maps include 1) distribution of population, 2) Fault zones in the County, and 3) Flood zones in the region. Thus final map will show the delineated areas where the population will be potentially affected by both of these hazards. There is a large area in Clark County where the population is near zero, the risk will be assumed to be low in these unpopulated regions, and thus not included in the analysis. Some assumptions such as buffered hazard zones around fault and flood features will simplify the analysis.

IDENTIFICATION OF AREAS IN LAS VEGAS WHERE EARTHQUAKE DAMAGE COULD OCCUR USING GIS

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Las Vegas, Nevada, with a population of about 1.9 million, is the most populous city in Nevada and a popular tourist destination. According to the USGS PSHA, there is a 15-20% probability of a magnitude 5 earthquake near Las Vegas within the next 20 years. By combining and analyzing existing fault, soil type, topography, and land use data sets using GIS, this project attempts to identify some of the areas in Las Vegas where damage due to an earthquake might occur.

ANALYSIS OF MICROVERTEBRATE SITES USING GIS, GPS, AND REMOTE SENSING TECHNOLOGIES

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The relationships between microvertebrate sites over time can be plotted using Geographic Information System (GIS). GIS offers a framework for elevation analysis of Blancan age fossiliferous deposits of Panaca local fauna in Meadow Valley. Global positioning systems (GPS) for field collection and ArcGIS ArcMap, a computer based program, work well together. GPS mapping units provide 1 to 3 meter accuracy for location coordinates of longitude and latitude in the collection of microvertebrate site data. GIS is a good tool for creating and analyzing spatial information, and for viewing collection site localities of fossils over time. Microvertebrate site location data from previous researchers can be plotted on separate layers and overlaid on present work. Program properties and attributes allow for building data attributes for location coordinates and elevation, field number, site history, deposition type, nature of fossil material, and locality condition. In addition, ASTER satellite imagery and aerial photography can be used to map soil composition geospatially across a changing landscape based on the material's reflectance spectrum. Ground surveying is compared with imagery to determine if lacustrine, fluvial, and eolian sediments in the Panaca formation show variance in reflectance in order to create a soil model to determine where potential microvertebrate sites may occur in the formation.

IDENTIFYING POTENTIAL COSTUMERS FOR THE RECLAIMED WATER IN LAS VEGAS USING GIS

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Las Vegas is located in the middle of the Mojave Desert, and is very hot and dry during summer with mild winters, and plenty of sunshine all year around. In the heigth of summer, during July and August, the temperature increases to above 100° F (38°C). A strong effort on water conservation is required, because Las Vegas recives only 4 inches of rain per year. Golf courses are traditional users of the reclaimed water in Las Vegas. The small users such as small-scale landscapes, pools, and public restrooms could be connected to the reclaimed water system. Enhancing the reclaimed water system seems very urgent to support the sustainable growth of Las Vegas. Using GIS data bases, developed for the utility network and reclaimed water in Las Vegas, is a proper method to identify the potential new costumers. The pupose of this research is to link the available data on the reclaimed water from Clark County and the costumer billing record near the reclaimed water pipelines. A map of the existing and potential reclaimed water system was developed.

POTENTIAL INFRASTRUCTURE LOSS FOLLOWING AN EARTHQUAKE IN LAS VEGAS

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The possibility of an earthquake in southern Nevada has been a frequent topic of study. Southern Nevada has been ranked as the third most active state in the country for earthquake activity behind California and Alaska. Despite the high activity for earthquake activity, there has not been much emphasis placed on designing buildings or infrastructure to withstand earthquakes at the local university level. It is important to understand the possible damage to the infrastructure of Las Vegas as well as the capabilities to treat the injured population and to maintain safety and order. Facilities such as gas lines, cell towers, and power lines pose several threats to the valley and have the capability to critically limit communication within and outside the Las Vegas valley. Furthermore, the ability of hospitals to accept and treat the injured and the ability of police and fire departments to respond to calls will be severely limited at best. With the aid of a geographical information system (GIS), one is able to quantify the possible damage in the valley as well as determine techniques for crisis management that will provide the best survival scenario for all of the valley's residents.

AFFECTS TO LAKE MEAD'S WATER QUALITY FROM LONG A TERM DROUGHT

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In the likelihood of ongoing drought, the monitored contaminants in Lake Mead will most likely increase due to the combined effects of evaporation and continuing high flow rate of effluent discharge. A model has been developed to determine if Lake Mead will become toxic to aquatic life prior to depletion of the reservoir. The model also has the potential to determine if the system is irrevocably damaged or if the system can recover prior to reservoir depletion. It is assumed that once the river reaches the historic flood plain, the system will be at a recoverable state. Variables that are part of this model include: annual average water level drop, average annual contaminant concentrations form receiving waters, annual discharge from Hoover Dam, average annual discharge of urban runoff contaminant level concentrations, and current monitored contaminant levels of Lake Mead. These results may help encourage and plan better water reuse programs as well as more stringent water use regulations for southern Nevada.

FORMATION OF THE SLATTEMOSSA ORBICULAR DIORITE, SOUTHEASTERN SWEDEN

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The formation of orbicular plutonic rocks characterized by concentrically layered spheroidal structures is controversial. Growth mechanisms include: crystallization about a xenolith, growth from the core to the rim, and crystallization from the rim to the core. We test these growth models by studying orbicular Precambrian diorite at Slättemossa, southeastern Sweden. At this locality orbs are relatively rare, cropping out between a fault and the margin of a pluton, and range from 2 to 5 cm in diameter. Orbs have a core composed of diorite to monzodiorite and are surrounded by mafic and felsic layers. Mafic bands contain biotite, chlorite, epidote, and hornblende. Quartz, K-feldspar, and plagioclase comprise the felsic bands. Apatite is a common accessory mineral in both mafic and felsic bands; zircon is a rare accessory. Orbs sit in a matrix of diorite to monzodiorite similar in mineralogy to orb cores. One orb was cut into several sections and polished for mineral analysis using the JEOL model JXA-8900 EPMA in the Electron Microanalysis and Imaging Laboratory at UNLV. Feldspar chemistry was obtained from four locations in and adjacent to one of the orbs: 1) in the matrix 5 mm from the orb margin, 2) in the matrix at the orb margin, 3) in a felsic layer, and, 4) in the core of the orb. Results are summarized in the following table.

Location	Plagioclase	K-feldspar
Matrix	An5-15	Or75-85
Margin	An12-18	Or87-90
Felsic layer	An2-13	Or90-97
Core	An12-22	Or90-96

Despite similarities in mineral chemistry, these data can be used to test models for orb formation. Focusing on plagioclase, the anorthite component increases from matrix to margin, decreases in the felsic layer and then increases again in the core. The core contains the most calcic plagioclase. Similarities between core and matrix suggest that core monzodiorite represents the primary magma and is not a xenolith. Higher An content of core plagioclase suggests that the core represents a less evolved magma. The trend toward more sodic (lower An content) plagioclase from the core to the felsic layer indicates that the orb developed by crystallization of layers from more evolved magma from the core outward. This observation rules out any model that requires inward growth of orbs. In summary, our study demonstrates that the Slättemossa orbs grew from inside out. Cores represent crystallization from less evolved magma than the matrix and are not xenoliths.

ORIGIN AND DISTRIBUTION OF NEW-GROWTH ZIRCON DURING CRUSTAL ANATEXIS

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This thesis aims to address the origin and distribution of new-growth zircon during partial melting events in the crust. Migmatites represent partially melted systems, and are comprised of the leucosome (the melted portion) and melanosome (residual solids, or "restite"). In traditional segregation models, it is thought that melt moves down pressure gradients associated with deformation. This deformation-assisted melt segregation (DAMS) model predicts that the melanosome should contain inherited zircon that didn't participate in the melting event, while the leucosome should have new-growth zircon crystallizing from the melt. However, cathodoluminescence images and U-Pb dates of zircons separated from both melanosome and leucosome show discrepancies with the DAMS model, which suggest that a revised melt segregation model is needed.

I will test two models, Ostwald Ripening and melanosome crystallization, to determine the chemical diffusion in migmatite systems. Current melt segregation models don't adequately explain elemental distribution patterns in migmatites, which suggest that a chemical separation mechanism is working in tandem with the well-accepted DAMS model. Testing these hypotheses will be critical for understanding partial melting events in the crust. Zircon is also an extremely important geochronology tool for dating high-grade metamorphic rocks. Understanding how zircon interacts during partial melting, and where it subsequently recrystallizes is important, because it will help geoscientists understand their dating techniques.

The migmatites in the metamorphic core complex of the East Humboldt Range, Nevada would be an ideal sample suite. The region contains a recumbent fold, where I can sample both in situ migmatites and the fold hinge where mobile melt would have collected. I will start with meso-scale observations before doing analytical testing of hand samples or thin sections. Detailed petrography from thin sections will be needed to observe the textures, mineral assemblages and zircon distribution of the migmatites. Bulk analyses from x-ray fluorescence (XRF) will show Zr abundance, and bulk separation using standard heavy liquid and magnetic separation techniques will allow us to look at and compare a wide range of zircons from both leucosome and melanosome quickly. Using CL images as guides, U-Pb dating by secondary ion mass-spectrometry (SIMS) of zircons will distinguish inherited zircon cores from new-growth crystallization, as well as help determine the time-frame of migmatization.

MAGMA CHAMBER PROCESSES AT MUTNOVSKY VOLCANO, RUSSIA

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Mutnovsky Volcano, located near the southern end of the island arc volcanic system of Kamchatka, Russia, is a stratovolcano that has been active since the late Pleistocene. The volcano has had four caldera-forming events. The first three events erupted products that vary from basalt to rhyodacite and the latest eruptive center erupted basalts to basaltic andesites. Currently, heat from the volcano is driving an active geothermal system, which is being tapped to generate 62 MegaWatts (MW) of electricity. For my dissertation project I am testing hypotheses about the causes of the magma compositional heterogeneity, the driving forces for the eruptions, and the link between volcanism and dehydration and melting of the down-going slab sediments. I am using a variety of techniques to investigate these hypotheses, including thin section petrography, whole rock geochemistry, temperatures and pressures calculated from geothermobarometry, melt inclusion analyses, whole rock Sr and Nd isotope analyses, and isotopic analyses of glassy melt inclusions. This combined data set will constrain petrogenic processes that extend from the near-surface magma chamber to the slab/mantle-wedge interface. The results obtained thus far allow me to draw the following conclusions. The whole rock geochemistry of samples from all four eruptive centers suggests is consistent with volatile-induced flux melting of the mantle wedge.that Mutnovsky has a large component of fluid flux melting, which appears to be consistent across the four eruptive centers. Thermobarometry results are consistent with two models: 1) indicate that, if Mutnovsky is the product of ahas a single magma feeder system, it is progressively emptying from greater depththe top down; and 2), or, if Mutnovsky has separate conduitschannels beneath for each eruptive center, that they are becoming deeper with time.

KINEMATIC ANALYSIS REVEALS EXTENSIONAL MOVEMENT, TRINITY FAULT, KLAMATH MTS., NORTHERN CA

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The Trinity fault in the Klamath Mountains, Northern California is thought to mark the paleosubduction boundary between the Eastern Klamath terrane (EKt), an island arc sequence, and the Central Metamorphic terrane (CMt), which is subducted oceanic crust (Davis et al, 1965). This is supported by a thrust sense of shear gained from universal stage lattice preferred orientations (LPOs) in olivine crystals representing ductile deformation at mantle or lower crustal depths within the Trinity peridotite (Cannat and Boudier, 1985). In addition, foliations in the peridotite are subparallel to the dip of the fault and foliations in the CMt where proximal to the shear zone (Quick, 1981). This deformation occurred concurrent with the Silurian-Devonian subduction of the CMt based on Rb-Sr ages from CMt samples (Lanphere et al, 1968) and Devonian fish scales from associated volcaniclastic sedimentary rocks in the EKt (Savage, 1976). Data from Barrow and Metcalf (2006) show the formation of a retrograde metamorphic texture of rutile->ilmenite->titanite (sphene) indicating the likelihood of large scale exhumation from deep crustal levels. In addition, Early Permian ^{40}Ar-^{39}Ar in hornblende and muscovite in the CMt are associated with exhumation giving rise to the idea that there was a later extensional event on the Trinity fault (Barrow and Metcalf, 2006).

Field mapping was conducted in summer 2009 and asymmetric folds were found in impure marbles and micaceous quartzites. Initial analysis of these features shows top to the east motion consistent with extension along the Trinity fault. Oriented sample collection following the guidelines of Passchier and Trouw (2005) was also performed during field work. Preliminary petrographic and microprobe study has yielded included garnet porphyroclasts, sheared feldspar porphyroclasts, and abundant mica fish within the micaceous quartzite supporting an episode of extension. A normal microfault was found cutting a quartz vein in a sample of the impure marble indicating that extensional movement could have occurred both above and below the brittle-ductile transition.

The next steps include continued microprobe analysis, geothermobarometry, electron backscatter diffraction (EBSD) analysis. Zoned porphyroclast analysis and increased data for thermobarometry are the goals of the microprobe analysis. Unfortunately, a lack of biotite precludes the use of the GB thermometer and the GASP barometer. The recently developed garnet-muscovite (GM) thermometer and garnet-muscovite-plagioclase-quartz (GMPQ) barometer of Wu and Zhao (2006) will be used instead. LPO data will be collected from micaceous quartzites and impure marbles to independently corroborate the extensional sense of shear.

Reception and Silent Auction
Immediately following GeoSymposium

2nd floor of Lilly fong Geoscience building
(4:00 PM)

Beer and wine available for only $2/per drink

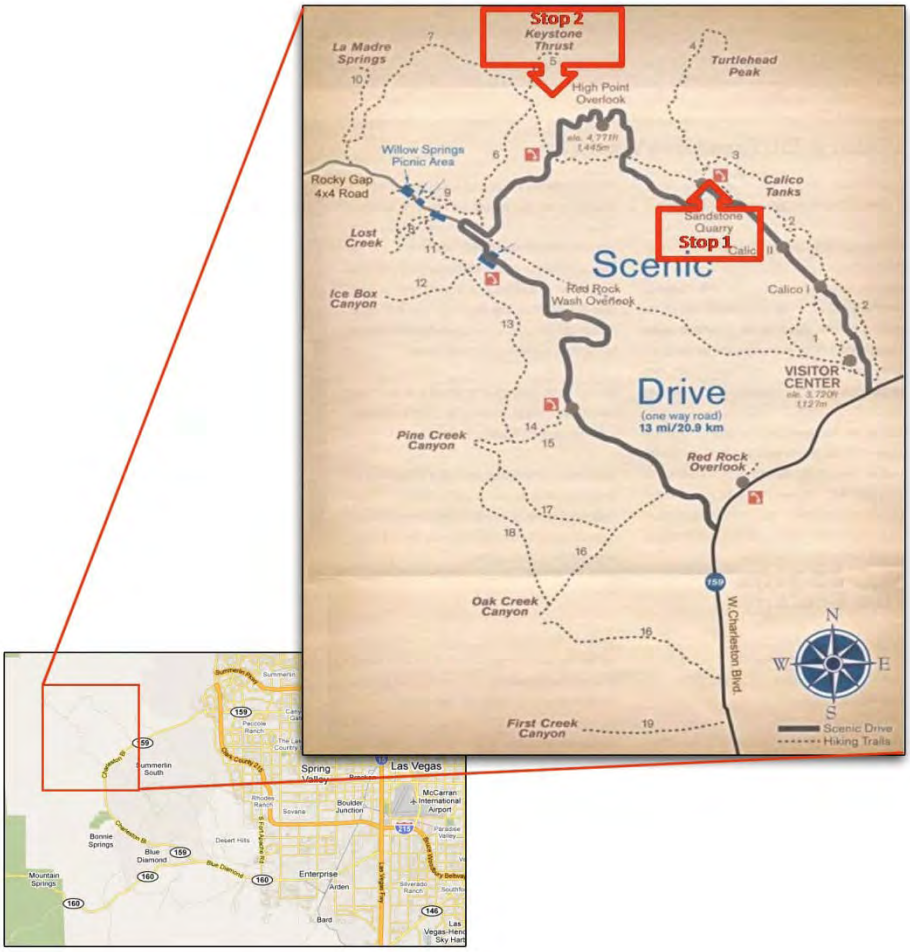
Appetizers and refreshments served

Silent auction

Minerals, rocks, and other geology related items available for bidding

Proceeds go towards next year's geosymposium

FIELD TRIP TO RED ROCK CANYON NATIONAL CONSERVATION AREA



Saturday, April 17: Schedule of Events:

8:30 am: Meet at the Lilly Fong Geoscience Parking lot, leave for field trip. Return around 5:00pm.

We will make a short stop at the Visitor Center after entering the Conservation area.

Stop 1. Sandstone Quarry – Offers good vantage points for photographs of crossed-bedded Aztec sandstone, easy walking access to the sandstone. Stop at the Sandstone Quarry parking lot to see large blocks of stone and other historic evidence of the quarry activity as it occurred shortly after the turn of the century.

Stop 2. From the upper White Rock Spring parking lot take the trail across the wash, and up the hill. The Keystone Thrust Trail "Ts" off the La Madre Springs loop to the right approximately ¼ mile from the parking lot. Take the right fork up the parking lot. Take the right fork up the stairs to where it joins an old jeep road, continuing uphill to the left. The trail transverses a low ridge, heads down into a small canyon, onto Keystone Thrust Fault where the gray limestone meets the red and tan sandstone. [2.2 miles round trip, moderate hike.