Department of Geosciences
Oral Presentations

Thursday March 30th

Student Union Memorial Center
North Ballroom

8:30 AM – 5:00 PM
Characterization of hydrothermal alteration in the Tucson Mountains using multispectral ASTER data

Wyatt M. Bain

Department of Geosciences, The University of Arizona, Tucson, Arizona

North Ballroom, 8:45 AM, March 30, 2017

Much of the world’s metal resources are derived from porphyry deposits. As a result, the exploration and development of porphyry systems is a vital aspect of the economy of the American southwest. Porphyry deposits are formed from hydrothermal fluids associated with crystalizing magmas in the subsurface, and are characterized by systematically distributed zones of mineralization and alteration. In recent years, multispectral data sets, such as those collected by the ASTER instrument on NASA’s Terra satellite, have proven valuable for identifying alteration zones in porphyry systems exposed at the earth’s surface. Given the public availability of multi-spectral ASTER data and the ease with which it can be processed and analyzed with common geospatial software (such as arcMap), there is enormous potential in applying this data to porphyry resource exploration.

Here we present ASTER near-visible infrared (NIR), short wave infrared (SWIR), and thermal infrared (TIR) data from the southern Tucson Mountains and the surrounding area. This locality contains a variety of igneous and sedimentary lithologies, as well as areas of porphyrystyle alteration and mineralization. By using principal component analysis, minimum noise fraction, vegetation masking, band ratio images, and supervised classifications we have characterized the distribution of lithologies and hypogene alteration zones coincident with known sites of porphyry mineralization. These results illustrate how ASTER data can be reliably used for exploration mapping and vectoring in hydrothermally altered terrains. Future work will focus on using multi-spectral data to delineate the relationship between structural features and the distribution of hydrothermal alteration. We will also work to develop band ratios and vegetation masks sensitive to the vegetation and rock-types endemic to the southwestern United states.
Geologic study of the Gold Hill District, Tooele County, Utah

Jason Burwell\(^1\)

\(^1\)Department of Geosciences, The University of Arizona, Tucson, Arizona

North Ballroom, 9:00 AM, March 30, 2017

The Gold Hill district, which sits on the western edge of Utah at the north end of the Deep Creek Mountains, contains information pertaining to the deformation and development of the eastern Basin and Range. Igneous activity in the Mesozoic and Cenozoic provide a diverse history of intrusions and volcanism that are linked to several mineralizing events, although the specific details are still unknown. Contractional events in the Mesozoic have been overprinted by later Cenozoic extension and metamorphism creating a complex history of deformation and supplying the area with a unique structural arrangement. Within the Gold Hill district lie the Clifton and Willow Springs mining districts, some of the oldest mines in Utah, which successfully produced significant amounts of arsenic, silver, gold, copper, lead, and lesser quantities of zinc, iron, tungsten, bismuth, and molybdenum. Classifications of many deposit types, including veins, pipes, and replacement bodies, have been attempted but little work has been done to understand hydrothermal processes and ore formation. Because the district is home to so many deposits that are markedly different, Gold Hill represents a unique opportunity to unravel a possible link between the mineralizing events of very chemically and mineralogically distinct ore bodies. This study will focus on the characterization of the main igneous phases in the area, along with a detailed analysis of the primary and secondary mineral assemblages. Information gained from mineral data on the electron microprobe will be used to estimate thermobarometry data, depth of emplacement, and the fO2 state of the magmas. Additionally, this project covers detailed thermobarometry analyses with U-Pb zircon ages, but also aims to establish and enhance both U-Pb Titanite and U-Pb Allanite dating procedures. This involves figuring common lead proportions, ratio percent errors, Concordia diagrams, and other calculations necessary for determining accurate age dates.
Ajo mining district, Arizona: Laramide porphyry copper mineralization and mid-Cenozoic sodic-calcic alteration

Simone E. Runyon

1Department of Geosciences, The University of Arizona, Tucson, Arizona

North Ballroom, 9:15 AM, March 30, 2017

The Ajo district contains a Laramide granodioritic porphyry Cu-(Au-Mo) deposit associated with New Cornelia pluton, exhibits Na-Ca alteration spatially associated with mid-Cenozoic Cardigan Peak pluton, and has been overprinted by Cenozoic extension. Data from maps and drill holes, new U-Pb zircon age dates, mineral compositions on minerals associated with Na-Ca alteration, and an estimate of emplacement depth from Al-in-hornblende thermobarometry on the New Cornelia pluton help to elucidate the geologic history of the Ajo mining district.

The New Cornelia pluton, responsible for porphyry-style mineralization, intruded into Cretaceous Concentrator Volcanics, and has been rotated ~100-120° S/SE. The outline of the New Cornelia pluton narrows from northwest to southeast in map view, as alteration progresses from K-silicate to sericitic, i.e., from deeper to shallower levels. Mineralization is dominated by a relatively sulfur-poor association of bornite-chalcopyrite-molybdenite with K-feldspar-quartz-secondary biotite-anhydrite-magnetite-tourmaline-rutile gangue, with superimposed pyritic associations related to sericitic alteration. Two periods of supergene enrichment are recognized; one chalcocite blanket dips ~30ºS, the other blanket parallels the pre-mine topography.

West of the Gibson Arroyo fault, a Proterozoic pluton and its gneissic wall rocks are intruded by the 23-25 Ma Cardigan Peak pluton. Na-Ca alteration overprints the Cardigan Peak pluton and is caused by the circulation of nonmagmatic external brines. Widespread chlorite overprint within the New Cornelia pluton and surrounding Concentrator Volcanics likely formed from circulation of dilute meteoric fluids during the Cenozoic.
Fluid evolution of the Saginaw Hill hydrothermal system

Wyatt M. Bain

Department of Geosciences, The University of Arizona, Tucson, Arizona

North Ballroom, 9:45 AM, March 30, 2017

Saginaw Hill is a small Laramide-aged porphyry-type system located on the western flanks of the southernmost extension of the Tucson Mountains. This system is associated with porphyritic igneous rocks and is characterized by several meters of unidirectional solidification textures (USTs) which host abundant primary, secondary, and pseudosecondary fluid inclusions in well-defined fluid inclusion assemblages (FIAs). The work presented here is in progress and attempts to reconstruct the physical and chemical evolution of magmatic hydrothermal fluids in the Saginaw Hill system by characterizing the paragenetic relationships and P-T-X conditions recorded in individual FIAs. These data will provide uniquely detailed information on the evolution of exsolving magmatic fluid at Saginaw Hill. Using these data, we aim to evaluate models for mass transport and partitioning of elements between melt, crystals, and aqueous fluid(s) in porphyry hydrothermal systems.

UST samples from Saginaw Hill host abundant primary aqueous FIAs that occur in both well-developed growth zones (apparent in transmitted light and in cathodoluminescence images) and in the cores of euhedral quartz crystals. These inclusions typically contain H2O liquid, H2O vapor, one to two translucent daughter crystals (halite and sylvite) and an opaque daughter crystal that ranges in shape from round to triangular. Many primary inclusions, particularly those which occur within the cores of euhedral quartz crystals, also include additional translucent daughter crystals which have an irregular shape and are birefringent in polarized light. Secondary FIAs occur in quartz along healed fractures (featureless gray or black quartz in cathodoluminescence images) which crosscut quartz growth-zones. These secondary FIAs are generally comparable to the primary FIAs and also typically contain H2O liquid, H2O vapor, one to two translucent daughter crystals (halite and sylvite) and an opaque daughter crystal which ranges in shape from round to triangular; however, no birefringent daughter crystals are observed in secondary FIAs.
Formation Conditions of the Casting Copper Skarn, NV, Based on Spectroscopic Analysis and Elastic Modelling of Mineral Inclusions

Drew W. Barkoff

1Department of Geosciences, The University of Arizona, Tucson, Arizona

North Ballroom, 10:00 AM, March 30, 2017

As rocks are exhumed from Earth's interior to Earth's surface, the accompanying decrease in temperature and pressure cause minerals in the rock to expand or contract according to the compressibility and thermal expansivity of each phase. When crystallites of minerals are completely encapsulated within a rigid host crystal, the elastic differences between the inclusion and host can cause the inclusion to either build up pressure (expansion greater than that of the host), or to develop tensile stress (expansion less than that of the host). Raman spectroscopic analyses were used to quantify the pressure in mineral inclusions, as the magnitude of the Raman shift for characteristic molecular vibrations is proportional to pressure. The measured peak shift and associated inclusion pressure can be used as a basis for elastic modeling to estimate the original pressure conditions under which the mineral inclusion was enclosed, and thus, the conditions at which the rock formed. In this study, we estimate formation pressures of a Cu-Fe-sulfide-bearing andradite-diopside skarn deposit at Casting Copper (Yerington district, NV) using Raman spectroscopy and elastic modelling of apatite inclusions in garnet. Andradite garnet from the Casting Copper skarn contains inclusions of hydroxyl-fluorapatite, calcite, hematite, magnetite, and ilmenite. Raman spectroscopy reveals that the apatite inclusions are predominantly under tension of ~50 to -150 MPa at ambient conditions. Elastic modelling of apatite-in-garnet systematics restores these inclusions to entrapment pressures of ~30 – 100 MPa, at inferred trapping temperatures of 400–550 °C, consistent with paleodepth constraints of ~ 2–3 km. These results provide independent constraints on the conditions of hydrothermal skarn metasomatism and mineralization at Casting Copper, and suggest that this approach may be applied to other, less-constrained skarn systems.
Modeling the Solubilities of Minerals in Saline Aqueous Fluids

Hanna Brooks

1Department of Geosciences, The University of Arizona, Tucson, Arizona

North Ballroom, 10:15 AM, March 30, 2017

Transport of heat and materials as well as chemical reactions in geologic systems are driven and controlled by fluids. Current approaches to thermodynamic modeling of fluid-driven processes typically invoke only simple, dilute H2O or H2O-CO2 fluids. However, these assumptions have significant shortcomings, when compared to data on natural fluids. Fluid-inclusion studies reveal that highly saline fluids are common in many environments including subduction zones, metamorphic complexes, and magmatic-hydrothermal systems – indicating that fluids are significantly more complex and contain high concentrations of various solutes. The effects of significant salt concentrations on high temperature, high pressure fluid properties are not trivial: Firstly, high salinities strongly affect activity-composition relationships in thermodynamic modeling; secondly, mixing high salt contents with gas-rich fluids (i.e., containing CO2 and other volatiles) leads to fluid phase immiscibility which partitions solutes and affects mineral stability relations. Thus, thermodynamic models accounting for multi-component, multi-phase fluids are needed for robust modeling of reactions and mass/energy transport in natural systems.

Approaches to modeling of concentrated solutions (“brines”) pose significant obstacles in terms of both the standard state properties and the activity coefficient models. Current modeling has been completed using the experimental mineral solubilities of quartz, calcite, corundum, fluorapatite, fluorite, portlandite, and rutile in order to determine the effects of pressure, temperature, salinity on density, volume of the mixture, and equilibrium constant. This information is required for future enhancements of models for fluid-rock reaction and mass transport. Our approach represents fluid-rock reactions involving multiple components over wide ranges of bulk salinity, ranging from subduction zones and high-grade metamorphic environments to crustal hydrothermal systems.
Formation age and conditions of Neoproterozoic basement-hosted Tava sandstone injectite by combined (U-Th)/He dating and fluid-inclusion studies of hematite

Jordan L. Jensen

1Department of Geosciences, The University of Arizona, Tucson, Arizona

North Ballroom, 10:30 AM, March 30, 2017

The Tava sandstone is a network of basement-hosted clastic dikes of unknown age that extend throughout the Colorado Front Range, USA. Here, we combine low-temperature thermochronology and fluid-inclusion microthermometry to better resolve the emplacement age, formation conditions, and subsequent thermal history of this enigmatic sandstone injectite. Specular hematite veins from Tava dikes were targeted for (U-Th)/He dating and microthermometry of fluid inclusions using infrared-light microscopy. Microthermometric data from hematite-hosted, primary fluid inclusions indicate that hematite was precipitated by an aqueous fluid at a minimum temperature of 200-250 °C and salinity >20 wt % (NaCl equivalent). Hematite (U-Th)/He dates show a positive correlation between hematite grain size (crystal plate width) and (U-Th)/He date, with dates plateauing at ~700 Ma for plates greater than 30 µm in width. Younger dates for thinner plates (plate widths <~30 µm) are consistent with post-formation heating to the partial retention zone (~120-140 °C) of the thin plates before cooling rapidly to surface temperatures during Laramide unroofing. As a result, the thicker plates have likely been helium-retentive since formation and thus their He dates reflect the timing of formation. Collectively, these data suggest that the Tava sandstone was emplaced during the early Cryogenian, contemporaneous with major rifting in western Laurentia and widespread Sturtian glaciation. We conclude that the combination of extensive rifting and glacial activity likely provided ideal conditions for the forceful injection of liquefied sediment into faulted basement.
Thallium: A geochemical tool within ore-forming systems

Shelby Rader

1Department of Geosciences, The University of Arizona, Tucson, Arizona

North Ballroom, 10:45 AM, March 30, 2017

Thallium (Tl) concentration anomalies have been useful vectors of mineralization for a variety of ore-forming systems for a number of decades now, from copper-molybdenum deposits to Carlin-type gold mineralization to Kuroko-type ore. Given the unique geochemistry of Tl, behaving as both a lithophile and chalcophile element and having multiple valence states (Tl⁺ and Tl³⁺), it has the dual ability to substitute for similar alkali elements such as Rb⁺ and K⁺, but also for geochemically similar Ag⁺ and Pb²⁺. When in the reduced state, Tl⁺ is similar to the alkali metals, and as such is rendered highly incompatible during magmatic processes and can be easily mobilized during hydrothermal fluid flow. However, the tendency to favor covalent bonding also allows for the incorporation of Tl in some sulfides. The geochemistry of thallium lends itself to enrichment in a variety of ore-forming systems, either during crystallization from magmatic and metamorphic processes or during hydrothermal fluid flow and alteration.

This study presents Tl concentration and isotope ratio data from a number of igneous and hydrothermal systems to understand the utility of Tl in geochemical exploration. Mineral separates were obtained from over eighty localities globally and analyzed for initial Tl concentrations, along with Pb concentrations and isotope ratios. Following this first-stage data acquisition, Tl isotope ratios were collected from pure Tl fractions obtained via anion-exchange chromatography. Published data show natural isotopic fractionations greater than 30ε, equivalent to 3‰; mineral samples analyzed in this study show variability greater than 50ε, a much larger range than anticipated. Preliminary evidence suggests that crystal chemistry, redox state, and Tl availability greatly influences Tl enrichment and isotopic signature in ore-forming systems.
Decomposition of the Atlantic meridional overturning circulation transports in CMIP5 models and the RAPID/MOCHA array

Rebecca L. Beadling

1Department of Geosciences, The University of Arizona, Tucson, Arizona

North Ballroom, 11:15 AM, March 30, 2017

Transports associated with the Atlantic Meridional Overturning Circulation’s (AMOC) upper limb at 26.5°N are investigated in 10 climate models contributing to the Coupled Model Intercomparison Project Phase 5 (CMIP5). The AMOC is decomposed into its major components at 26.5°N: the wind driven Ekman transport, Florida Straits transport, and the geostrophic Upper-Mid Ocean transport. The component transports are calculated closely following the definitions used to estimate these components in the RAPID/MOCHA observational array at 26.5°N. Annual mean transport and the seasonal cycle of each component simulated in the CMIP5 models is compared to that estimated by the RAPID/MOCHA array over the past decade of available observations. The projected changes of each component throughout the 21st century under the RCP8.5 climate scenario are investigated to gain insight on the mechanisms governing AMOC decline in the different models analyzed. With a decade of continuous, trans-basin observational estimates of the AMOC available, we now have the data to begin to evaluate climate models on their ability to simulate the oceanic transport components associated with the AMOC. The ability to project changes in future climate relies on the ability to realistically simulate oceanic transports in fully coupled climate models. Previous studies that have evaluated model simulated AMOC transports against the RAPID-Array estimates have been limited by the use of ocean-only numerical models rather than coupled models that are used for future climate projections. The results of this study show a wide spread among models in their ability to simulate the mean transports and seasonal cycle of the AMOC and its components relative to the RAPID/MOCHA estimates. The models also widely differ in the changes projected in response to 21st century climate forcing. This study is the first model intercomparison study using the RAPID/MOCHA estimates to evaluate and understand projected changes in CMIP5 models.
The Tropical Pacific Ocean has a powerful influence on global and regional climate, from the interannual timescales of the ENSO phenomenon to decadal and longer term changes. However, the short length of sea surface temperature (SST) instrumental data limits our ability to understand the climate variability in the tropical Pacific. Geochemical signals (e.g. $\delta^{18}$O and Sr/Ca) in corals provide an alternative to extend the instrumental data further back in time. While $\delta^{18}$O and Sr/Ca are the most commonly analyzed geochemical tracers in corals, they may exhibit site-specific complications. Li/Mg is a more recently proposed SST proxy and may be free of those complications in other tracers, thus helping us to reduce uncertainties in paleoclimate reconstructions. Here, we develop a new method by using an ICP-OES to detect lithium, magnesium, and barium contents in two coral heads from the Galapagos Archipelago (from Darwin and Wolf Islands). We specifically analyze the Li/Mg content of the corals and determine whether this proxy is a good SST recorder. We further analyze the Ba/Ca signal from these two corals to understand the upwelling variations in the region. By combining upwelling and SST variation proxies, we will better constrain the processes associated with past climate variability in this region, in turn improving our understanding of the mechanisms underlying modern changes and how the region may behave in the future.
Ocean warming near the Antarctic ice shelves has critical implications for future ice sheet mass loss and global sea level rise. Two eddying climate models are used to quantify and better understand the mechanisms contributing to CO2-forced ocean warming above the Antarctic continental shelf. The largest warm anomalies occur within the top 100 m and at depths just above the shelf floor. These two warming regimes are controlled by different mechanisms. The near-surface warming is modulated by warmer atmospheric temperatures, changes in sea-ice coverage, changes in air-sea heat flux, and increased onshore advective heat transport into the shelf region. The deep warming is initiated by surface freshening which limits vertical mixing of heat. This reduction prevents heat associated with the Circumpolar Deep Water from diffusing upwards through the water column. Within a few years of a surface freshening anomaly, an affiliated temperature anomaly response occurs at depth. Here, we focus on the very large temperature anomaly in the Ross Sea. Understanding the drivers of this temperature anomaly and others around Antarctica will lead to better projections of future ice sheet mass loss and global sea level rise.
Response of the East African climate to global forcings in a family of earth system models

Zachary Naiman

1Department of Geosciences, The University of Arizona, Tucson, Arizona

North Ballroom, 12:00 PM, March 30, 2017

East African climate change over the last few million years is often associated with hominin evolution. Here we examine the impact of various global forcings on East African climate using a family of Earth System Models from NOAA's Geophysical Fluid Dynamics Laboratory. We present results from four types of experiments: quadrupling of atmospheric carbon dioxide, fresh water "hosing" of the North Atlantic, removal of mountains and opening of the Panama ocean gateway. Removal of mountains results in a much wetter East Africa. Raising carbon dioxide levels results in a slightly wetter East Africa, and the other experiments have almost no impact on East African climate.
Investigating crustal deformation due to water distribution using GRACE and GPS data in the Amazon Basin

Lisa Jose¹

¹Department of Geosciences, The University of Arizona, Tucson, Arizona

North Ballroom, 3:45 PM, March 30, 2017

This project concerns the redistribution of water on Earth's surface, with the aim of determining how this redistribution will impact groundwater storage. I am comparing the uplift signal from continuous GPS data with JPL's GRACE gravity data, with the assumption that regional uplift can be estimated based on the gravity signature of crustal loading. I use GRACE data from the Amazon basin, where loading signals are strong enough to compare with the GPS signal. This study aims to overcome the high degree of scatter in the time series of the GRACE spherical harmonic coefficients using an appropriate fit to the time series to best capture the annual signal in the coefficients. An F-test is used to ensure that the fit for annual variation in the coefficient time series is sufficient to reduce the scatter present. Using the estimated GRACE coefficients that adequately reflect the seasonal variability, we estimate vertical displacement values across the Amazon basin. We conduct a variance analysis between the estimated displacements and the actual GPS displacements to ensure that the fit is viable. Comparing GRACE water loading with GPS displacements is an excellent tool to monitor how and where the groundwater levels will respond to natural or anthropogenic influences. A major limitation to the use of cGPS for these types of investigations that researchers are currently confronting is how to interpret the GPS time series data. I also overcome this limitation by providing a detailed assessment of the relationship between water loading and GPS site motions.
The South American Andes, generated along an active oceanic-continental convergent margin between the Nazca and South American plates, are the world’s longest and second highest orogenic belt. Along-strike variations in shortening, slab subduction angle, and volcanism, as well as other tectonic processes have created significant variations in topography, crustal thickness, and seismic character of crust and mantle rocks. In an attempt to elucidate some of these variations we use Ps receiver functions obtained from over two decades worth of teleseismic, ≥ M 5.9 earthquakes, recorded by broadband and short period seismic instruments across the Central Andes. In areas of highly thickened crust, previous studies have suggested that eclogitization of lower crustal rocks may be in the early stages of delaminating from the crust, while other regions may have already experienced delamination. Both eclogitization and delamination, as well as a host of other tectonic processes, create changes in the impedance contrast at the Moho. This study investigates variations in the amplitude of Ps conversions at the Moho in order to better understand the nature of the Moho.
An Earthquake Triangle: the Sordid Backstory Behind the 27 February 2010 Mw 6.1 Salta Earthquake

Phillip McFarland

1Department of Geosciences, The University of Arizona, Tucson, Arizona

North Ballroom, 4:15 PM, March 30, 2017

The 27 February 2010 Mw 6.1 Salta earthquake occurred in the active retroarc fold-thrust belt of northwest Argentina approximately 9 hours after and 1500 km away from the Mw 8.8 Maule earthquake. In this study, we examine a transient signal in the east component of position recorded at the continuously operating GPS (cGPS) station UNSA, which lies approximately 32 km to the northeast of the Salta earthquake epicenter. The transient signal is observed in the roughly 2.3 years prior to the Salta earthquake. It begins immediately following the 11 November 2007 Mw 7.7 Tocopilla megathrust event that occurred about 550 km due west of Salta and terminates abruptly after the Salta earthquake. We use the published relocated main shock and aftershock hypocenters determined using data from a local seismic network (INPRES) along with the published main shock focal mechanism to demonstrate that the Salta earthquake likely occurred on the Golgota Fault, a N-S striking and steeply-east-dipping reverse fault. Further, it is shown using elastic dislocation modeling that rupture on the Golgota Fault is consistent with the co-seismic offsets observed at the surrounding cGPS stations. We demonstrate that the observed transient at station UNSA is likely due to initiation or acceleration of interseismic strain accumulation on the freely slipping section of the Golgota Fault following a change in the regional stress field associated with the Tocopilla earthquake and propose that rupture of the locked section of the Golgota Fault was dynamically triggered by the passage of seismic waves following the Maule earthquake.
Evolution of the southern Guinea Plateau: Insights from exploration geophysics

Jared Olyphant

1Department of Geosciences, The University of Arizona, Tucson, Arizona

North Ballroom, 4:30 PM, March 31, 2017

The Guinea Plateau, offshore Guinea, and its conjugate Demerara Plateau, offshore French Guiana, comprise two of the most prominent passive continental margins in the Atlantic Ocean. The conjugate plateaus formed as a result of two periods of rifting, the Jurassic opening of the Central Atlantic Ocean and the northward propagating Cretaceous opening of the Southern Atlantic Ocean. Although several studies are published on the Demerara Plateau that explain the evolution of its multi-rift history with respect to its distinct geometry, the Guinea Plateau, and in particular its south-eastern margin, remain relatively unexplored in the literature. Here we present interpretations on the structure and evolution of the Guinea Plateau using new 2-D and 3-D seismic-reflection data recently collected at the intersection of the southern and eastern margins. We substantiate our study with calculated subsidence curves at four locations along the southern margin, as well as two 2-D gravity forward models along regional seismic-reflection lines to estimate stretching factors ($\beta$) and crustal thicknesses, respectively. We combine our results with previous studies concerning the south-western Guinea margin, and compare them to published interpretations regarding the conjugate margins of the Demerara Plateau. The resolved amounts of rift-related volcanism, listric-style normal faults, and muted stretching factors reason us to suggest that a component of upper-crustal asymmetry (simple shear) and depth-dependent stretching may have persisted at the Demerara-Guinea conjugate margin during Cretaceous rifting of the equatorial segment of the Southern Atlantic Ocean.
Subduction in the Eastern Mediterranean: Insights from new teleseismic P-wave tomography

Daniel Evan Portner

Department of Geosciences, The University of Arizona, Tucson, Arizona

North Ballroom, 4:45 PM, March 30, 2017

The last vestige of the closure of the former Tethyan Ocean through Africa-Arabia-Eurasia convergence drives plate dynamics in the Mediterranean region, making it one of the most tectonically complex regions on earth. Through its complexity, it is becoming increasingly clear that subducted Tethyan lithosphere and its effect on mantle dynamics play a starring role in Mediterranean tectonics. Contrary to Cordilleran-type subduction, subduction in the Mediterranean is characterized by slow convergence and slab roll-back, detachment, and flattening in the mantle transition zone.

With an improved teleseismic P-wave tomography model beneath the Anatolian subcontinent I show that the Eastern Mediterranean does not exactly fit the typical Mediterranean framework of subduction. I compile data collected over the last 17 years from more than 300 seismic stations, including from the CD-CAT array - a new, dense, 71 station array across central Turkey - and use them in a continent-wide finite-frequency tomography inversion. With this, I have a new model of P-wave velocities in the upper 900 km of the mantle beneath Anatolia. The new model reveals fast velocities representing the subducted Aegean slab extending continuously from the surface throughout the upper mantle and into the lower mantle. Similarly, the slab expected to lie in the transition zone beneath eastern Turkey is not present, suggesting it may have sunk into the lower mantle. Meanwhile beneath central Turkey, the Cyprian slab appears to be highly deformed as it traverses horizontally beneath the Central Taurus Mountains and descends steeply into the transition zone, eventually passing into the lower mantle as well. These results show that the Eastern Mediterranean behaves differently than the traditional Mediterranean subduction model, providing context for the unique tectonic character of the Anatolian sub-continent.
Friday March 31\textsuperscript{st}

Student Union Memorial Center
North Ballroom

8:30 AM – 1:00 PM
Plio-Pleistocene climate variability of East Africa as seen in an HSPDP drill core from Tugen Hills, Kenya, and possible implications for hominin evolution

Anne L. Billingsley

Department of Geosciences, The University of Arizona, Tucson, Arizona

North Ballroom, 8:30 AM, March 31, 2017

A 227 m drill core was collected from the Tugen Hills, Kenya as part of the Hominin Sites Paleolake Drilling Project (HSPDP), an international collaboration aimed at collecting high-resolution records of paleoclimate of East Africa and through these records, developing a more comprehensive understanding of the environmental context of hominin origins. 40Ar/39Ar dates indicate that the core record spans the 3.4-2.55 Ma interval, providing a rare African terrestrial record of the important Plio-Pleistocene transition, when global climate began to cool, glaciation intensified in the Northern Hemisphere, C4 grasses expanded further in East Africa, and African climate became more arid and variable. Furthermore, this time period brackets important hominin milestones such as the first appearance of both Paranthropus sp. and Homo sp. and the development of the Lomekwian and Oldowan technologies. Single spectrum analysis (SSA) and wavelet analysis of total organic content, high resolution magnetic susceptibility, and gamma density records indicate that on a regional level, global and continental changes are reflected by orbitally driven cycles. These cycles contain periods of increased climate instability followed by relatively stable conditions, when amplitude of variability is muted in all three data sets. The periods of stability documented in the Tugen Hills core correlate temporally to two faunal turnover events at nearby Lake Turkana, suggesting that both locations experienced environmental shifts simultaneously, presumably in response to regional or global shifts. The reconstructed series created from the SSA will ultimately provide a framework on testing models of hominin evolution such as Variability Selection or Accumulated Plasticity using developed links between global and local climate change in the rift valley.
Phytoliths and charcoal show no major change in East African flora after the 75 ka Toba supereruption

Chad Yost¹

¹Department of Geosciences, The University of Arizona, Tucson, Arizona

North Ballroom, 8:45 AM, March 31, 2017

The temporal proximity of the 75 ka Toba supereruption (YTT) to a Late Pleistocene human population bottleneck is the basis for the Toba catastrophe hypothesis, which states that the YTT eruption caused a 6 year global volcanic winter and reduced human populations to fewer than 10,000 individuals. The magnitude of an eruption's atmospheric sulfur injection is the primary driver of volcanic induced climate change. YTT melt inclusion studies and a Greenland ice core record have suggested a 50 to 100 Mt SO2 atmospheric loading; however, most YTT climate models use loadings that are 1 to 2 orders of magnitude higher, producing global cooling estimates of 3 to 18 °C. To test the Toba catastrophe hypothesis and potential vegetation change associated with the YTT, we sampled two cores collected in Lake Malawi with cryptotephra previously fingerprinted to the YTT. For each core, phytolith and charcoal analysis was conducted on 30 samples above and 15 samples below the YTT at ~3–4 mm (~8–9 yr) intervals, with no stratigraphic breaks between adjacent samples. For samples synchronous or proximal to the YTT interval, we found no change in low elevation tree cover, or in cool climate C3 and warm season C4 xerophytic and C4 mesophytic grass abundance that is outside of normal variability. A spike in locally derived charcoal immediately following the peak in YTT cryptotephra suggests a die-off of at least some Afromontane vegetation at elevations susceptible to freezing. The strongest component of the record was a trend in decreasing tree cover, and increasing aridity and fire frequency as ice core δ18O values rapidly decreased during the transition from Greenland Interstadial 20 to Stadial 20. With no evidence of a major vegetation perturbation linked to the YTT, future climate models should use SO2 loading magnitudes suggested by YTT melt inclusion studies.
Lake Ayauchi: A 400 year record of Amazonian hydrology

Nicollette Buckle¹

¹Department of Geosciences, The University of Arizona, Tucson, Arizona

North Ballroom, 9:00 AM, March 31, 2017

The Amazon Rainforest is a carbon sink and a center of biodiversity, and as such plays a critical role in the global climatological and ecological systems. In the last decade, two widespread single year droughts alerted us to sensitivity of the Amazonian ecosystem. Both droughts were deemed once in a century events and exposed the limited perspective of the 30-year satellite record, paucity of ground-based measurements, and the need for longer records. We have analyzed sediments from Lake Ayauchi, a permanent, closed basin lake located in the Western Amazon basin, to improve understanding of past climate and hydrology. Using temperature and moisture sensitive proxies including grain size, elemental concentration, magnetic susceptibility and organic content, we have identified several multi-year hydrological events that occurred during the past ~400 years. Identifying and characterizing these events extends the climatological baseline of observations, quantifies historical variability in the Amazon Basin, and will help us to understand hydrological changes that may occur in a warming world. Our results highlight the possibility that multi-year drought events can occur in the Amazon, and thus such events need to be taken into consideration in carbon management and biodiversity conservation efforts.
Forests in the southwestern U.S. are experiencing higher mortality as a consequence of higher temperatures brought on by global warming. However, the long-term effects of climate variability on forest composition are not well understood, and necessary to support effective management of these forests in the future. Paleoenvironmental studies from lakes provide an opportunity to assess long-term changes in forest ecosystems and climate. Lipid biomarkers from leaf-waxes, in particular, are promising as indicators of temperature change over these longer timescales. This study examines the last 550 years of temperature change using the average chain length (ACL) of n-alkanes at North Bullberry Lake (NBL) in central Utah. The subsequent response of vegetation to temperature change was assessed by analyzing pollen changes over the same period. Fire history was also reconstructed from charcoal accumulation rates as another potential disturbance agent of vegetation change. ACL-reconstructed temperature indicates that mean annual temperatures reached up to 1-2 degrees higher than modern, yet the pollen composition at NBL remained nearly unchanged. Further, presence of large-scale fires were not supported by the charcoal analysis. These results indicate temperature changes of this magnitude did not cause large scale changes in vegetation composition, but that the forests around NBL were generally resilient to these changes in climate over the last 550 years. This study is small step in understanding what is the minimum ecological “safe zone” for temperature change for maintaining these forests in the face of future climate change.
Paleoclimate reconstructions from the northeastern United States using tree-rings

Jessie Pearl

Department of Geosciences, The University of Arizona, Tucson, Arizona

North Ballroom, 9:30 AM, March 31, 2017

High-resolution paleoclimate records are essential for improving detection and attribution of internal and forced climate system responses. The densely populated northeastern United States is at high risk from increasing temperatures, changes in storm intensity and frequency, droughts and floods, and sea level rise. The region has limited annual or seasonal-scale proxy climate records beyond the instrumental record. Here we present a network of Atlantic white cedar tree-ring chronologies across the northeastern United States. Ring width variability reflects winter through summer temperatures at inland sites in the northernmost section of the species’ range. Multivariate climate signals embedded in the full northeastern network are evaluated for their potential to provide reconstructions of both temperature and drought variability. We demonstrate skillful climate reconstructions for the last several centuries and the potential to use sub-fossil samples to extend these records over for the past 2000 years. Our tree-ring network provides the long-term context at multidecadal and centennial time scales for the large-scale ocean-atmospheric processes that influence the climate of the region.
The Mars Science Laboratory (MSL) rover, Curiosity, is analyzing rock and sediments in Gale crater to provide in situ sedimentological, geochemical, and mineralogical assessments of the crater’s geologic history. Curiosity’s recent traverse through an active, basaltic eolian deposit, informally named the Bagnold Dunes, provided the opportunity for a multi-instrument investigation of the dune field.

Prior to Curiosity’s arrival at the Bagnold Dune Field, orbital observations characterized the geomorphology and predicted the mineralogy of the dunes. Orbital spectral analyses range from several km² to higher spatial resolutions on the scale of individual dunes. In situ analyses were conducted by the CheMin X-ray diffraction instrument which analyzed the mineralogy of the <150 µm fraction of sediment, named Gobabeb. Gobabeb is dominated by basaltic minerals and X-ray amorphous phases. Plagioclase, olivine, and two Ca-Mg-Fe pyroxenes comprise the majority of crystalline phases; minor minerals include magnetite, quartz, hematite, and anhydrite. The identity of specific amorphous phases cannot be unambiguously determined from CheMin diffraction data. However, the chemical composition of the amorphous component along with the orbital spectral predictions can suggest the nature of potential constituents comprising the X-ray amorphous component of the sand.

Overall, the predicted mineralogy based on orbital spectral measurements shows high fidelity to in situ CheMin mineralogical analyses at Gobabeb. This unique ground-truth comparison can be used to validate and improve upon spectral models, as well as provide information regarding possible amorphous phases which may be ambiguous or poorly constrained in surface measurements.
Mineralogy Characterization of the Gefion Asteroid Family

Allison McGraw¹

¹Department of Geosciences, The University of Arizona, Tucson, Arizona

North Ballroom, 10:15 AM, March 31, 2017

Here we present results of our initial observational campaign to verify a link between the Gefion asteroid family and L-chondrites. Near-infrared (NIR) spectra (0.7-2.5 μm) of asteroids (2386) Nikonov, (1839) Ragazza, (2373) Immo, (2521) Heidi and (3860) Plovdiv were obtained at the NASA Infrared Telescope Facility (IRTF) located on Mauna Kea, Hawaii. The spectral data was reduced using the IDL-based software Spextool. Spectral band parameters including Band center, and the Band Area Ratio (BAR) were measured using a Python code. Based on our results we found that some members of the Gefion family have composition similar to H-chondrites, primitive achondrites and basaltic achondrites. We found no evidence for L-chondrites among the Gefion family members in our small sample study. Our observations partly support this finding as we found (1839) Ragazza and (2521) Heidi to have compositions similar to H-chondrites. The three other asteroids with non-ordinary chondrite compositions might be interlopers in the Gefion family.
The Tajik fold and thrust belt: Implications for intracontinental subduction

Jay Chapman

1Department of Geosciences, The University of Arizona, Tucson, Arizona

North Ballroom, 10:45 AM, March 31, 2017

A regional, balanced cross-section is presented for the thin-skinned Tajik fold and thrust belt, constrained by new structural and stratigraphic data, industrial well-log data, flexural modeling, and existing geologic and geophysical mapping. A sequential restoration of the section is calibrated with 15 new apatite (U-Th)/He ages and 7 new apatite fission track ages from samples of the major thrust sheets. Thermokinematic modeling indicates that deformation began during the Miocene and continues to the near present with long-term shortening rates of ~4 to 6 mm/yr and Pliocene to present rates of ~6 to 8 mm/yr. Deformation initiated at opposite margins of the Tajik foreland basin, adjacent the southwest Tian Shan and northwest Pamir Mountains, and propagated toward the center of the basin, eventually incorporating it into a composite fold-thrust belt. The western thrust belt records at least 35-40 km of total shortening and is part of the greater Tian Shan orogenic system. The eastern thrust belt records ~30 km of shortening that is linked to the Pamir Mountains. The amount of shortening in the thrust belt is significantly less than predicted by models of intracontinental subduction that call for subduction of a 300 km long slab of continental lithosphere beneath the Pamir. We propose that the south-dipping zone of deep seismicity beneath the Pamir, which is the basis for the intracontinental subduction model, is related to gravitational foundering (by delamination or large-scale dripping) of Pamir lower crust and mantle lithosphere. Delamination may explain the initiation of extension in the Pamir gneiss domes and does not require a change in boundary forces. Because the Pamir is the archetype for active subduction of continental lithosphere in the interior of continental plates (intracontinental subduction), the viability of this particular tectonic processes may need to be reassessed.
Miocene orogeny-perpendicular extension and exhumation of the Alichur dome, South Pamir, Tajikistan

James Worthington

1Department of Geosciences, The University of Arizona, Tucson, Arizona

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Neogene tectonic exhumation of lower–upper Asian crust in the Afghan–Tajik Central and South Pamir along mylonitic, low-angle, normal-sense shear zones produced an orogen-parallel gneiss-dome system that accommodated strain in the northwestern India–Asia collision zone. The Alichur–Shakhdara gneiss-dome complex in the South Pamir spans a ~400 km east-to-west increase in topographic relief that correlates with an increase in magnitude and younging of exhumation. The ~125 x 25 km Alichur dome (in the east) is bounded to the north by the normal-sense, mylonitic–brittle, top-to-NNE Alichur shear zone and comprises: (i) Middle–upper-crustal, Jurassic–Cretaceous continental-arc granitoids and Cretaceous gneisses in the footwall; and (ii): Permian–Jurassic strata and the Triassic (meta)mafic Bashgumbaz complex, both of which are intruded by Jurassic–Cretaceous continental-arc granitoids in the hanging wall. The footwall is pervasively intruded by ~22–18 Ma leucogranites (new zircon U–Th/Pb geochronology), which transition from foliation-parallel, cm–m-thick bodies within the Alichur shear zone (in the north) into discordant, enveloping bodies that comprise as much as half of the volume of the dome in its core (in the south). New and previously published thermochronometric ages (white-mica/biotite/K-feldspar/plagioclase $^{40}$Ar/$^{39}$Ar, zircon/apatite fission-track and U–Th–Sm/He) bracket tectonic footwall cooling between ~400–80 °C from ~16–4 Ma. Single-sample cooling rates span ~20–60 °C/Ma in the footwall and ~1–5 °C/Ma in the hanging wall. At the orogen scale, the timing of tectonic exhumation and cooling of the Alichur dome provides a link between that for the Shatput–Muskol domes in the eastern (Tajik) Central Pamir and the Shakhdara dome in the western (Afghan–Tajik) South Pamir and indicates a broad, WSW-younging propagation of orogen-perpendicular (~N–S) extension that we attribute to tearing of the Indian lithospheric slab.
Cenozoic Magmatism in the Pamir: a geochemical investigation of syn-collisional intrusive rocks

Shane Scoggin

Department of Geosciences, The University of Arizona, Tucson, Arizona

North Ballroom, 11:15 AM, March 31, 2017

The Pamir Mountains of Central Asia are part of the Himalayan-Tibetan orogenic system and collectively represent the archetype for tectonic models of continental collision. One of the intriguing aspects of the Tibet-Pamir orogen is that magmatism continued even after subduction of oceanic crust ceased in the early Cenozoic. In the Pamir Mountains, the youngest magmatism is thought to be Eocene in age based off detrital zircon U-Pb geochronology, however, the source region and geologic context for these detrital zircons is unknown. In this study, we report on a belt of Eocene age granitoids from the Central Pamir terrane that is the likely source for this magmatic event. We dated these plutonic rocks with U-Pb zircon geochronology and analyzed them for zircon δ¹⁸O, zircon εHf, whole rock εNd, and whole rock ⁸⁶Sr/⁸⁷Sr isotopes. We also examined whole rock major and trace element geochemistry. The results suggest that there is an unrecognized Eocene magmatic arc that formed well-away from the plate boundary immediately following India-Asia collision. Future work will focus on using the geochemistry to constrain the geodynamic processes that produced these magmas.
Tracking the growth of the Himalayan fold-thrust belt in the Early Miocene foreland basin strata, Dumri Fm., western Nepal

Simon Stickroth

1Department of Geosciences, The University of Arizona, Tucson, Arizona

North Ballroom, 11:30 AM, March 31, 2017

Investigation of the Dumri Formation, in western Nepal, provides new insight on exhumation of the Himalayan fold-thrust belt and provenance of the foreland basin system. The Miocene Dumri Formation has an age of 20-15Ma in Central and Western Nepal, dated by paleomagnetostratigraphy. Thermo-geochronology can provide valuable information on understanding the evolution of the Himalayan fold-thrust belt and foreland basin system during the early Miocene. We use detrital U-Pb zircon, Th-Pb monazite, Ar-Ar white mica and zircon fission-track on measured stratigraphic sections in the Dumri Formation to determine provenance signals and timing of exhumation of Himalayan source regions in response to tectonics. Greater Himalaya Sequence (GHS) detritus into the Dumri Formation in Western Nepal shows evidence for a low-grade to unmetaphorphosed protolith of the GHS recorded by a cluster of Proterozoic to Early Paleozoic monazites. Meanwhile an ~8Myr lag time in zircon fission-track peak ages record the onset of rapid exhumation on the Main Central Thrust from ~20-15Ma coeval with deposition of the Kamal Bajar section of the Dumri Formation.
Interrelationships of cataclasite, mylonite, leucocratic bodies and the Catalina detachment fault

Triffon Tatarin

1Department of Geosciences, The University of Arizona, Tucson, Arizona

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The structural components of metamorphic core complexes consist of an upper plate, detachment fault, cataclasite and chlorite breccia, sub detachment fault, and mylonites. Within the Dual Wash area, two west-northwest-trending washes (Deer Valley and Carillo) provide excellent cross-section exposures of metamorphic core complex fault rock units, including the Catalina detachment fault, which strikes NE. Within the Carillo Wash (to the south), the Catalina detachment fault dips ~13° NW, which is consistent with its overall dip in this part of the Rincon Mountains. However, as exposed along the Deer Valley Wash (to the north), the Catalina detachment fault dips more steeply at ~60° NW. Beneath the detachment fault, in the lower plate, the structurally highest rock is a highly-fractured chlorite cataclasite. This unit is ~ 0.25 km thick. Embedded in this unit is a massive, highly fractured, white aplitic leucocratic granitic unit which floods the cataclasite. This leucocratic unit does not appear to be mylonized, even within the mylonitic zone, where it also occurs as sill-like bodies. It was anticipated that a sub detachment fault would sharply separate the cataclasite and the mylonites. However, throughout the Dual Wash area, no sharp distinction is seen, but instead a gradational transition. The first sign of mylonites are ~1km east of the detachment fault in Deer Valley Wash, which provide great exposures and sense-of-shear indicators.

The structural geology of the Dual Wash area proves to be structurally anomalous compared to what has been mapped to the south in the Loop Drive area of Saguaro National Park. The cause for much of these anomalies within the lower plate may be credited to the presence of this abundant leucocratic unit, which does not appear in classic core complex stratigraphy.
The Northern Andean Volcanic Zone contains a unique locality where a volcano assimilates rocks that span the entire crustal column. The Granatifera Tuff is a satellite cone of the Doña Juana volcanic complex near the town of Mercaderes, Colombia. Located in the Central Cordillera of the Northern Andean Volcanic Zone, it is the only active continental arc setting where xenoliths (pieces of assimilated country rock) from the entire crustal column are concurrently found. Compared to other xenolith occurrences, such as those from the central Sierra Nevada (Ducea and Saleeby, 1998a; Chin et al., 2012) or Camp Creek, Arizona (Esperança et al., 1988), Mercaderes is also unique due to its large petrographic variety.

This study will focus on establishing the source of the crustal assemblages. The preferred hypothesis is that the lower crustal rocks have formed as a result of melt extraction related to subduction processes, which led to the formation of igneous rocks observed at the surface today. An alternative theory is that some of the lower crustal lithologies may be the result of underplating of oceanic material or a mid-ocean ridge basalt (MORB) magma source. In order to test these models, the study will employ petrographic analysis, geochemical analyses, thermobarometry and forward modelling.
Exhumation of the Cordillera de Domeyko since Late Cretaceous: A record of the early tectono-thermal history of the central Andes

Susana Henriquez

Department of Geosciences, The University of Arizona, Tucson, Arizona

North Ballroom, 12:15 PM, March 31, 2017

The Central Andes, the widest and thickest part of the Andes, provides a unique geologic record to study how Cordilleran-type orogenic system evolves through time. It growth has been widely documented in the modern retroarc region, showing an overall eastward propagation of the orogenic wedge during the Cenozoic. The Eocene was a time a major reorganization as shown by the expansion of the orogen at 38-40 Ma, the attainment of high elevation in the proto-Puna plateau, widespread shortening and the formation of the Bolivian Orocline. Although most part of the present architecture of the orogen was form during the Cenozoic, the forearc region records a Late Cretaceous to Eocene foreland basin related to an earlier compressional history. One of the key datasets that helps to constraint the time and amount of deformation in the orogenic wedge is low temperature thermochronology. The post mid-Eocene cooling, erosion and exhumation history has been documented in the retroarc, however, the exhumation in the previous orogenic wedge, the first half of Andean history, remains unknown. In order to constrain the early cooling history related to exhumation, we employed a multi-dating approach combining apatite fission track and apatite (U-Th)/He thermochronology. We targeted the eastern edge of the Cordillera de Domeyko, the easternmost basement uplift, and the Late Cretaceous to Miocene sedimentary rocks that record the unroofing history of it. The new apatite fission track and apatite (U-Th)/He data show episodic cooling in the orogen during Late Cretaceous, Paleocene and Eocene. The easternmost basement uplift records a period of exhumation between 65 and 45 Ma related to active thrusting in the retroarc. The estimates for erosion rates suggest that the exhumation was decreasing between 80 and 40 Ma, and that no significant erosion happened after the Miocene, probably related to the dry climate and high elevations.
Reconstructing the tectonic history of the Sierra Pampeanas through low temperature thermochronology: A case study in Sierra Velasco

Andrea Stevens

Department of Geosciences, The University of Arizona, Tucson, Arizona

North Ballroom, 12:30 PM, March 31, 2017

The Sierras Pampeanas mountains in west central Argentina are basement-cored uplifts ranging between 2 – 6 km in elevation that dissect the Andean foreland. Prevailing ideas suggest that these basement block uplifts were exhumed during a period of flat slab subduction that initiated in the mid to late Miocene. This study presents new apatite fission track and apatite (U-Th-Sm)/He data from the Sierra de Velasco, a major peak in the Sierras Pampeanas tectonomorphic zone. We use thermal modeling that incorporates the annealing and diffusion kinetics of the apatite fission track and apatite (U-Th-Sm)/He systems respectively to produce a time-temperature history from 320 Ma to the present. The results of these thermal models require some topography in the Sierra de Velasco as early as the Carboniferous, likely a slowly eroding mountain system. Rifting in the mid to late Cretaceous inverted some of this topography and buried parts of the mountain system. Final exhumation of Sierra de Velasco began by 20 Ma. We propose that a similar tectonic history can be extrapolated throughout the region. These results have important implications for understanding the effects of flat slab subduction on surface geology. Specifically, this study suggests that in the Sierras Pampeanas region the current model linking flat slab subduction to the initial exhumation of basement cored ranges must be amended to account for preexisting topography.