M001 Sabiha Tabassum

**Response of Streamflow to Climate Change in the Colorado River Basin**

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U-Pb detrital zircon geochronology has become a routine approach to modern provenance analysis. The continuously increasing application of detrital geochronology has been paralleled by growing interest in using the maximum depositional age (MDA) to constrain the depositional age of sedimentary units. The efficacy of using a deposit’s MDA to constrain its true deposition age (TDA) is contingent on the deposit having contemporaneous (e.g., volcanic) zircon. However, applications of using a deposit’s MDA to constrain its TDA rarely consider the specific nature of arc-derived sediment (i.e. plutonic versus volcanic). We seek to test the hypothesis that the efficacy of utilizing the MDA as the TDA is contingent on the deposit’s relative influence of undissected vs dissected arc provenance. To test this hypothesis, we will evaluate detrital populations from the classic arc-unroofing sequence of the Great Valley Group in central California. Sandstone compositions from the Great Valley Group reveal a temporal transition from undissected to dissected arc sediment shedding (Ingersoll 1983), making it an ideal study area to evaluate our hypothesis.

We compiled published datasets of U-Pb detrital zircon from the Great Valley Group (Surpless et al 2002, Orme and Surpless 2019, Wright and Wyld 2007). Samples were grouped into their geologic formations in order to visualize the temporal progression of undissected arc to dissected arc. The arc dissection progression documented in the stratigraphy was then compared to the time lag between the unit’s calculated MDA versus independent depositional age constraints. Preliminary results from each stratigraphic unit show that there is both an increase in the relative contribution of dissected arc sediment and in the lag time between MDA and TDA from oldest to youngest geologic formation. We hypothesize that this trend in the MDA/TDA divergence and relative contribution of dissected arc input is influenced by not only the abundance of contemporaneous zircon, but also a bias in grain size and fertility between plutonic (dissected) and volcanic (undissected) zircon sources.

Future work aims to study the size, shape and abundance of plutonic vs volcanic zircon in the Great Valley Group. Additionally, we will compare zircon characteristics in modern sediments from the Central Valley of California which drain a spatial progression of undissected arc sources (northern Sacramento River) to dissected arc and basement uplift sources (southern San Joaquin River; cf. Ingersoll and Eastmond, 2007). Results of this work will elucidate the controls on the geological conditions best suited for MDA applications. Moreover, the results aim to quantify the relative composition and contributions of arc sources needed to yield an MDA that tightly constrains a deposit's age.

**Keywords:** Climate Change, Streamflow, Water Resources Planning

M002 Liam Norris

**Reconstructing Dinosaur Ecology and Niche Utilization in the Jurassic Using Calcium Stable Isotopes in Teeth**

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Stable calcium isotopes can preserve information about diet and ecosystem structure in the fossil record

that might not be discernable from body fossils alone. Studying these isotopes has allowed for a greater

understanding of many ecosystems, and here we apply it to an Late Jurassic North American ecosystem.

Sauropod dinosaurs are the largest known terrestrial herbivores, and here we studied isotopes from the

teeth of two sauropods, Camarasaurus lentus and Diplodocus longus, and one theropod, Allosaurus

fragilis, to determine niche partitioning between herbivores and if these herbivores were being eaten by

this significantly smaller carnivore.

The Morrison Formation preserves abundant large-bodied herbivores, including multiple types of

sauropods. The large size of these animals suggests that food would be scarce in an environment with this

many herbivores, and niche partitioning would be necessary to have so many large species in a single

locality. Their large size also suggests that predators would not actively hunt large prey, but would

preferentially seek out young, old, or injured individuals. We hypothesize that C. lentus and D. longus

occupied different niches and will preserve isotope ratios indicative of feeding on upper and lower

canopy, respectively. We also hypothesize that A. fragilis will preserve calcium isotope ratios consistent

with modern predator-prey isotope fractionation.

Here we examine δ 44 Ca of carbonate preserved in the enamel of C. lentus, D. longus, and A. fragilis.

Higher Ca isotope ratios indicate higher browsing in the canopy, and modern predators preserve lower

δ 44 Ca values than their prey. Using this information, we will hypothesize the diet of these Late Jurassic dinosaurs.

**Keywords:** Paleontology, Geochemistry, Paleoecology

M003 Sinjini Sinha

**Assessing the benthic community structure in the Early Jurassic of Morocco**

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Early Jurassic hyperthermal events triggered by the eruption of the Karoo-Ferrar Large Igneous Provinces

resulted in varying degrees of marine biotic crises, particularly at the Pliensbachian/Toarcian boundary,

approximately 183.5 million years ago and during the Toarcian Oceanic Anoxic Event (TOAE), approximately 183 million years ago. Some of the cascading effects of the Karoo-Ferrar eruptions include higher sea temperatures, ocean acidification, marine deoxygenation and eutrophication associated with continental weathering. Despite due to several geochemical studies, the exact causes of the extinction are debated, likely due to limited paleoecological data availability from non-European shallow water carbonate deposits. Therefore, to investigate the exact kill mechanism causing the late Pliensbachian-early Toarcian extinction events, we studied the change in community structure of the level-bottom communities from the Central High Atlas Mountains of Morocco. Previous works from the targeted intervals have identified rapid shifts in lithology from carbonates to siliciclastic inputs (or no to minimal carbonates) following the Pliensbachian/Toarcian stage boundary and during the TOAE in response to environmental changes. Krencker et al. (2020) referred to these shifts as a two-phased carbonate factory collapse (reduction in carbonate production) and correlated them to environmental perturbations in these intervals. Biotic changes among the communities living in carbonate shelves in Morocco are coincident with these carbonate factory collapses, but recovery of carbonate deposition was rapid (e.g., Krencker et al., 2020). Therefore, quantification of the occurrences and abundances of fauna from the late Pliensbachian to the early Toarcian stages sheds light on the significance between the cause and community dynamics amongst the organisms due to these extinction events. Here, we report diverse groups of bivalves, ammonites, echinoids, gastropods, and brachiopods, with taxonomic classification down to species level, where possible. The taxonomic assessments and the quantified data of the level bottom fauna show that community structure changed in response to multiple environmental conditions such as ocean warming, acidification, eutrophication. Due to a relatively smaller number of species range studies from the tropical carbonate shelves community as compared to geochemical studies, it is crucial to understand the extinctions at the Pliensbachian Toarcian boundary and during the early Toarcian in Morocco. The Early Jurassic extinction events are not recognised amongst the biggest five mass extinction events, despite being caused by the same environmental conditions as the end Permian or end Cretaceous. Studying the recovery of organisms from severe biotic crises such as the Early Jurassic hyperthermal sheds light on the survival strategies of organisms through environmental perturbations analogous to modern day. Therefore, this study will not only provide new data about Early Jurassic

shallow water tropical communities, but will also aid in developing conservation strategies for modern marine organisms.

**Keywords:** Karoo-Ferrar Large Igneous Province, Toarcian Oceanic Anoxic Event, Level-bottom communities, ocean warming, ocean acidification, Carbonate factory collapse

M004 Veronika Redensek

**Nonlinear Impact of Aerosols and Irrigation on the Surface Energy Balance**

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South Asia’s population growth, agricultural expansion, and aerosol emissions in recent decades correlate with an observed weakening of the summer monsoon. Surface forcings such as aerosols and irrigation disrupt the surface energy balance, influencing the temperature gradient and stability through changes in energy and moisture availability at the surface. Although climate impacts of these forcings have traditionally been considered separately, both aerosol emissions and irrigation interact with the climate system through similar pathways and may interact nonlinearly. To better understand the mechanisms by which these forcings have a nonlinear influence on the monsoon, their dual influence on the surface energy balance must be better understood. Using transient simulations from the GISS-E2-1-G model, I compare the separately modeled effects of aerosols and land use and land cover changes with dual-forcing simulations to assess the potential for these nonlinear interactions. Analyzing the 30-year model mean change in surface energy balance components between the preindustrial (1850- 1879) and present (1985-2014) shows potential nonlinearities in downwelling shortwave, downwelling longwave, and upward sensible heat flux. The null hypothesis of the difference between linearly added single forcing simulations and dual forcing simulations has a p value < 0.05, showing high confidence over much of the Indian subcontinent. This demonstrates that there is a simulated difference between individually forced and dual forced models and may indicate that single forced models do not fully capture the potential climate impact which may be enhanced or suppressed via other overlapping mechanisms of anthropogenic forcings. Potential drivers of these nonlinearities include limitations on moisture availability as well as impacts on stability, convection, and mass transport. These results indicate that greater consideration should be given to aerosol and irrigation combined influence in model analysis and in projections of future impacts, as the response of the surface energy balance and subsequent climate variables to their dual influence may not be well predicted by simulated effects of the individual forcings.

**Keywords:** Climate, Land-Atmosphere

M005 Will Reyes

**New specimens of Calyptosuchus wellesi (Pseudosuchia: Aetosauria) from the Upper Triassic Chinle Formation of Petrified Forest National Park, Arizona, provide new details on the cranial anatomy and intraspecific variation of the taxon**

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Calyptosuchus wellesi is an aetosaur currently known from the upper Blue Mesa Member and lower Sonsela Member of the Upper Triassic Chinle Formation (northern Arizona) and the Tecovas Formation of the Dockum Group (northwestern Texas). Because of its restricted stratigraphical range, this taxon is considered biostratigraphically informative and provides a means of correlating upper Triassic strata in the southwestern United States (U.S.). Currently, our anatomical understanding of C. wellesi is based on a combination of the holotype specimen (UMMP 13950), a referred partial pelvis (UMMP 7470) from Texas, an associated skeleton (UCMP 27225), and an array of referred disarticulated elements from the Placerias Quarry of Arizona. Here, we present two new specimens referrable to C. wellesi that were collected from the upper Blue Mesa Member of the Chinle Formation within Petrified Forest National Park (PEFO), Arizona. PEFO 49321 includes associated maxillae with dentition, a jugal, quadratojugal, quadrate, laterosphenoid, surangular, prearticular, and articular. This provides new details of the skull morphology of C. wellesi allowing us to explore new phylogenetic hypotheses and assess the diet of this taxon. The second specimen, PEFO 46222, is a partial associated skeleton, preserving a nearly complete pelvis, vertebrae, and osteoderms from the trunk through caudal regions. PEFO 46222 provides new insight into the morphological variation of the osteoderms within the carapace of one individual; this includes variation in the development of the dorsal eminence and the degree of flexure of both the paramedian and lateral osteoderms across the various subdivisions of the carapace. Understanding the degree of variation in the aetosaur carapace is important for the biostratigraphic utility of aetosaurs. The preserved pelvic girdle of PEFO 46222 provides new details into the intraspecific variation of the non-osteoderm postcrania of C. wellesi. We document the first occurrence of co-ossified sacral vertebrae within C. wellesi ‚Äì the first documentation of this state outside the Desmatosuchini. We phylogenetically assess the referral of UMMP 7470, UCMP 27225, PEFO 46222, and PEFO 49321 to Calyptosuchus wellesi based on our re-analysis of the holotype of specimen UMMP 13950. This new understanding of the anatomy of Calyptosuchus wellesi brings to question the taxonomic affinities of elements referred to this taxon from the Placerias Quarry.

**Keywords:** Paleontology, Triassic, Chinle Formation

M006 Janet Canamar

**Scientific illustrations from the Vertebrate Paleontology Laboratory Collections.**

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When describing fossils through words in papers, readers are often unable to imagine the fossil explained, confusing them. Pictures and scans help provide context to the narrative. However, conflict begins when the imported image or scan provides a poor perception of what is in the paper. On rare occasions, figures are excluded from scientific papers for various reasons.  
We visited the Vertebrate Paleontology Laboratory collections every week to observe fossils from the naked eye and sketch onto paper what we see. We created illustrations of various kinds of fossils from different perspectives. This project revolves around dinosaurs and other Mesozoic fauna. We examined a diverse amount of fossilized dinosaur bones, including analysis of more recent fossils of the Cenozoic from the collections. Our finished illustrations range from metacarpals to teeth of dinosaurs and Cenozoic mammals.  
When comparing the results of hand-drawn illustrations to the pictures taken of the illustrated fossils, the artwork captured imagery that the photos couldn’t supply.  
Illustrating fossils from a still-life perspective helps catch details within fossils that cameras and scans fail to complete. Using artistry to draw incomplete fossils helps reimagine what the bone could look like if they had not eroded. Scientific illustration is essential in paleontology because creative visualization is necessary to piece together how extinct organisms looked, and to translate ideas that words cannot do.

**Keywords:** Paleontology, Illustration, Fossils

M007 Xinxin Sui

**Global urban precipitation anomalies**

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Urbanization is a global anthropogenic land surface change underway, which has been proven to modify both the global climate and regional extreme weather. Although researchers have investigated the urban influences on precipitation for specific cities or several thunderstorm cases, no study to date has revealed the urban precipitation anomalies on a global scale. This research analyzes the urban precipitation anomalies for over one thousand global cities in the past two decades. We found that over 60% of the cities and their downwind regions are receiving more precipitation than their surrounding rural control areas. The urban precipitation anomalies are unequal among different continents. African cities have not only large urban annual precipitation anomalies but also large urban extreme precipitation anomalies, while large Asian cities tend to experience negative precipitation anomalies. Three environmental factors are found to relate to the urban precipitation anomalies: urbanization extent, climate (wetness and temperature), and topographic conditions (coastal, inland, or mountainous areas). This research identifies the urban rainfall hotspots across the globe, which will help to project extreme precipitation in city areas and to develop more resilient cities under global warming.

**Keywords:** Urban climate, Hydrology, Precipitation

M008 Claire Williams

**Environmental Monitoring to Support Coral Reef Management in East Portland Special Fishery Conservation Area, Jamaica**

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Global warming and human impacts are and will continue to be devastating for coral reef systems. Jamaican reefs have been hit hard by a variety of threats including hurricanes, coral bleaching, disease, and algal overgrowth, the impact of which has been exacerbated by overfishing and urchin disease. Despite the dire situation, with proper protection, algal coral phase shifts can be reversed, and urchin populations are recovering. One region that is being protected is The East Portland Special Fishery Conservation Area (EPSFCA). The EPSFCA is a ‚Äúno take zone‚Äù monitored by the Alligator Head Foundation (AHF), which houses a coral nursery, mangrove nursery, and leads monitoring and restoration practices on the shoreline and in the ocean.  
Although reefs in some parts of Jamaica were well studied in the 1970s-early 2000s (e.g., Discovery Bay), many ecological studies have not continued, nor have they extended to other regions of the island. The unique reefs of Northeast Jamaica are especially understudied and lack critical data, such as baseline ecological surveys, necessary for conservation efforts. For example, no baseline information on community composition had been done until the establishment of the AHF. To obtain an ecological baseline, this project synthesized current community assemblage data from reefs in the EPSFCA (fish counts, benthic substrate assessments, and invertebrate counts conducted by AHF staff) and layers in environmental data that has been collected since June of 2022   
An analysis of EPSFCA reef sites monitored from 2017-2022 found that many sites are distinct from each other, but most of these reefs show signs of degradation (e.g. signs of coral disease and high algal cover). Environmental data indicates that these areas are potentially stressed by many factors including high temperatures, and occasionally high nutrient levels which fluctuate throughout the year.

**Keywords:** Paleoecology, Ocean Chemistry

M009 Katherine Faulkner

**The Long-Term Evolutionary Trends of Benthic Foraminifera**

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Foraminifera are single-celled protists that evolved and diversified throughout the Phanerozoic Eon and are found throughout marine ecosystems. They are used as proxies for paleoclimate reconstructions because the composition of their tests reflects conditions of their environment. Furthermore, foraminifera diversity and abundance are sensitive to several environmental and evolutionary factors, including ocean chemistry and climate. Over 47,000 foraminifera fossil occurrences have been recorded in The Paleobiology Database (PBDB). A preliminary examination of the database found biases within the foraminifera records towards certain intervals of interest and severely under-reported occurrences during most time intervals. For example, while the Late Cretaceous has a wealth of occurrence data and is thus likely reflective of true foraminiferal abundances, the Cambrian Period has little information about the species present. Foraminifera‚Äôs presence in the Cambrian is well known, and this merely reflects what data has been entered into the PBDB. This research project focuses on alleviating these biases by aggregating published foraminifera data based on occurrence, test mineralogy, etc. which can be added to the PBDB and greatly improve the foraminiferal information in this dataset. Moreover, compiling this foraminifera database will provide data on long-term evolutionary trends within the benthic foraminiferal community. The dataset will be built by recording the accepted names, life position, wall type, time interval, and location of every genus recorded in Loeblich and Tappan (1988), an exhaustive synthesis of foraminifera genera (up to its publication date) reflecting the opinion of a single pair of authors. Using this data, we tracked the diversity of these organisms through the Phanerozoic Eon, compared the relative proportion of calcareous vs. agglutinated foraminifera, and graphed the overall diversity. Comprehensive datasets such as this are essential for research about faunal diversity and paleoclimate records, ocean chemistry, and conservation. While an exhaustive foraminiferal dataset is beyond the scope of this undergraduate thesis, the dataset will be an important step towards incorporating foraminiferal records in Phanerozoic scale diversity assessments.

**Keywords:** Foraminifera

M010 Harsh Kamath

**Mapping Austin’s Heat Exposure using Remote Sensing and Modeling Methods**

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Austin, Texas is the 11th most populous city in the United States, one of the two state capitals

with a population exceeding 1 million. As a result of global warming and urbanization, Austin is

witnessing an increasing trend in number of days with air temperature exceeding 95 th percentile

of the climatological values. This is causing acute heat stress on the communities living in

neighborhoods that are susceptible to heat. We generate city-scale Heat Vulnerability Index

(HVI) map over Austin using Land Surface Temperature (LST) from remote sensing

observations combined with social-demographic indices (e.g., poverty) from recent US census to

identify vulnerable neighborhoods. Modeling approach is used to further understand the heat

exposure at high spatio-temporal resolution at urban blocks that are identified as vulnerable

using remote sensing approach.

We create three HVI maps: 1. Historical (2002-2020) to identify communities that have been

historically exposed to heat, 2. Trend in number of extremely hot days in a given year using to

identify locations that are experiencing changes in heat stress and will be vulnerable to heat in

the future, and 3. Present-day heat exposure to help design heat mitigation strategies.

Finally, high resolution modeled heat exposure is compared with public perception of heat. HVI

information will be conveyed to the city of Austin through an ongoing collaboration. This

information will be used by the city to design heat mitigation strategies such as increasing green

cover.

**Keywords:** Urban, Weather, Climate

M011 Sandra Juarez-Zuniga

**Detrital zircon provenance record of the Orogrande Basin, NM ‚Äì implications for the Ancestral Rocky Mountains unroofing history**

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The Ancestral Rocky Mountains (ARM) orogen is a late Paleozoic intra-continental shortening belt characterized by basement-cored uplifts and adjacent basins in SW Laurentia. While traditional models linked the ARM deformation to the far-field shortening in the foreland of the diachronous Marathon-Ouachita (MO) thrust belt during the final assembly of Pangea, this view has recently been challenged in light of alternative proto-Cordilleran tectonic models. Much of the uncertainty hinges on the paucity of temporal constraints on deformation and basin formation. This study investigates the deposition and provenance evolution of the Orogrande Basin (OrB) and the tectonic unroofing of the Pedernal fault block. The OrB is one of the southernmost ARM basins and is separated from the Pedernal Uplift by a series of late Paleozoic reversal faults. Geometry and progression of reverse faulting and the syn-tectonic sedimentary record are well exposed due to Cenozoic Basin and Range normal faulting and offer the opportunity to investigate the timing of ARM tectonism. Clastic sedimentation in the OrB initiated with the deposition of the early Pennsylvanian Gobbler Formation, it continued with the upper Pennsylvanian mixed carbonate and siliciclastic Holder and Bursum formations and early Permian non-marine Abo Formation. Detailed new detrital zircon (DZ) U-Pb geochronology from the Gobbler, Holder, Bursum and Abo formations show a 3-fold pre-, syn, post-tectonic depositional history. While lower Gobbler samples exhibit a pre-tectonic regional provenance signature likely derived from the Ouachita foreland, DZ provenance quickly shifted to a local-derived signature linked to unroofing of the Pedernal Uplift, dominated by Yavapai-Mazatzal, granite-rhyolite and recycled Grenville DZ ages and signaling the onset of ARM shortening. From the upper Gobbler through the lower Abo formations, DZ patterns remain very constant and dominate ages derived from the Pedernal block. The upper part of the Abo Formation is marked by a sharp shift to only ~1.25 Ga DZ age, indicating a second stage of ARM thrusting exhuming a single Grenville source while the western flank of the Pedernal block was buried. Overall, these DZ patterns in the proximal OrB indicate that ARM unroofing of the Pedernal Uplift started in the early Pennsylvanian and continued until the early Permian and hence largely predated shortening in the Marathon fold-and-thrust belt.

**Keywords:** Ancestral Rocky Mountains

M012 Erin Keenan Early

**Serial Water Incubations Show Growth and Adjustment of GDGT-Producing Bacteria to Temperature**

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Branched glycerol dialkyl glycerol tetraethers (brGDGTs) are bacteria-produced lipids recoverable from various environmental sources, including lake sediments, soils, peats, speleothems, and bone. Variations in the number of methyl branches and cyclopentane rings result in fifteen main types of brGDGT, and the relative abundance of these types within a sample correlates with mean annual temperature. As a result of this correlation, brGDGTs are widely used as a paleotemperature proxy. Despite this, it is not well understood which bacteria produce brGDGTs. Because the producers of the brGDGT temperature proxy have not been identified, the environmental factors that impact brGDGT development remain largely unconstrained. Calibration indices have, by necessity, been built using large numbers of environmental samples, potentially allowing conflating environmental factors (e.g. pH, DO, conductivity, soil moisture, etc.) to skew these indices in unknown ways.

We serially incubated water samples from three bodies of water in Central Texas (Palmetto Lake, Beuscher Lake, and Lake Travis) in twelve incubators ranging between 4¬∞C and 32¬∞C. Initial experiments show clear but sluggish response to the different temperature environments, with warmer temperatures showing greater responsiveness to incubation. Later incubations sought to highlight incubator growth by removing existing brGDGTs through filtration and inoculating the incubated waters with a scraping of the filter to replace removed bacteria. Doing so resulted in a better fit to the current calibration index for lake sediments. However, in all experiments cooler incubations show a plateau in response to incubation around 15¬∞C. Low brGDGT production under cold conditions does not account for this reduction in response to incubation temperatures. This indicates that another, as-yet unidentified variable is impacting brGDGT production at lower temperatures in our incubations.

Incubation of waters from a fourth body of water collected in Colorado (Little Molas Lake) is underway to explore the possibility that bacteria found in Central Texas waters are not suited to growth in lower temperatures, which could account for the plateau. Additionally, we intend to perform 16s rRNA sequencing to characterize the microbial community in our later incubation experiments in an effort to identify potential source bacteria for brGDGT production.

M014 Victoria Todd

**Insolation Forcing of mid-Holocene drought in the Southwestern US**

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During the mid-Holocene, the southwestern United States experienced drier conditions, with evidence of widespread drought throughout the Great Basin, Arizona, and New Mexico (e.g., Lachniet et al., 2020; Hermann et al., 2018). Early studies suggested that these hydroclimatic changes were associated with increased evaporation due to high temperatures (Holliday et al., 1989), northward movement of the wintertime storm tracks (Oster et al., Hermann et al., 2018; Lora et al., 2019; Salathe, 2006), or changes in the midlatitude westerlies associated with mid-to high-latitude temperature gradients (Routsen et al., 2019), However, other recent studies have argued that mid-Holocene aridity was associated with changes in the tropical Pacific (e.g., Ersek et al., 2012; Metcalfe et al., 2015; Steinmann et al., 2019). Here, we use new biomarker-based stable isotope and proxy temperature records from the Southern Rockies to better understand the causes of long-term hydroclimate changes in this region. Estimates of seasonal changes in moisture delivery from a Bayesian isotope mixing model suggest that this dominant control on mid-Holocene aridity in the southern Rockies was changes in the supply of winter moisture, which was reduced by as much as 20% between ca. 12 and 5.5 ka. A synthesis of published paleoprecipitation records from across North America is suggestive of a PDO-like pattern, albeit with important differences that may reflect other factors. Comparison with simulations of mid-Holocene climate (6 ka, PMIP3) substantially underestimate the magnitude of this drought and lack a clear PDO-like pattern, suggesting that models underestimate some of the mechanisms driving changes the wintertime storm track during this period.

**Keywords:** Climate, water

M015 Nicole Czwakiel

**APPLYING A MULTI-PROXY APPROACH TO THE DEVELOPMENT AND INFLUENCE OF A MEDITERRANEAN-TYPE CLIMATE ON THE IBERIAN PENINSULA**

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Mediterranean-type ecosystems (MTE) are some of the most biodiverse regions in the world, collectively representing ~20% of global vascular plant species. They represent five of the 25 biodiversity hotspots in the world. Today, the Mediterranean Basin experiences this climate, which is characterized by mild wet winters and hot dry summers. The combination of an MTC, environmental variation, geographical isolation, and heterogenous edaphic factors are thought to be responsible for the high biodiversity. However, this climate regime was not always in place, and is theorized to have appeared about 3.3 Ma, replacing a subtropical environment. In light of climate change threatening this water-limited region, it is important to understand the dynamics between climate shifts and the related vegetational responses. Does the vegetation change synchronously with the onset of a summer drought? Is there a vegetational response to climate shifts in the region? The purpose of this study is to apply stable oxygen isotope data from soil carbonates in Teruel, Spain as a paleo-rainfall proxy to advance understanding of the onset of the MTC in the basin. By evaluating stable oxygen isotopes from these carbonates, changes in the rainfall regime can be inferred. We can then compare this indicator of climate change with charcoal and previously published pollen and magnetic parameter records to better understand the vegetational-climatic relationship in this region. Our preliminary data shows a negative excursion of 1.8‰ from -5.2‰ to -7‰ at ~3.3 Ma, falling in line with the estimated onset of the MTC in this region and Marine Isotope Stage (MIS) M2, and a subsequent decrease of 1.5‰ from -4.7‰ to -6.2‰ during the onset of the Northern Hemisphere Glaciation (~3.1-2.7 Ma). These negative shifts in δ18O could result from a shift to winter-dominated rainfall, which has a lower δ18O value than summer rainfall, either through the onset of a summer drought or the intensification of winter rainfall through the southward shifted North Atlantic (NA) storm track during global cooling. Published work by our group of χfdrecords in the Teruel Basin suggest intensified precipitation during 3.3-3.18 Ma, which is synchronous with our recorded negative isotope excursion during the MIS M2 event and may provide support for the influence of a southward shifted NA storm track.

**Keywords:** Soil Processes, Paleoclimate

M016 Ting-Yu Dai

**Generating High-Resolution PM2.5 using a Two-stage Machine Learning Approach with Low-Cost Air Quality Sensors and Satellite Observations**

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*Pawan Gupta, NASA Goddard Space Flight Center*

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Using low-cost sensors (LCS) in air quality monitoring has increasingly garnered attention that applies in multiple disciplines including community and citizen scientists, academic research groups, and environmental agencies. LCS are widely used due to the advantages such as lower costs, minimal infrastructure requirements, and smaller footprints. However, two main barriers yet to be overcome in LCS are 1) spotty performance compared to regulatory-grade monitors (RGM), and 2) sparse spatial coverage compared to satellite products.  
  
For the first challenge, Gupta et al. (2022) applied a machine learning method to calibrate the LCS measurements with the Federal Equivalent Methods (FEM) values and confirmed the effectiveness of the machine learning method to correct the LCS data against FEM instruments.  
  
This study proposes an innovative approach to sidestep the above imperfections. First, we followed the bias-correction process described in Gupta et al. (2022) to calibrate the LCS estimations into FEM level based on their nearest RGM stations by a random forest (RF) model. This increases the accuracy and minimizes the uncertainty of the LCS data. Second, another RF model is implemented to quantify the PM2.5 under different weather and aerosol conditions. RF is a commonly used approach in determining air quality values due to its simplicity and diversity. Finally, the relationship between LCS, aerosol optical depth (AOD), and meteorological variables is established to generate a stable and continuous spatial data product.  
  
The approach is implemented in both San Francisco (SF), and Los Angeles (LA), CA from 2019 to 2020. 881, and 297 LCS stations in SF and LA, respectively, are used to test the impact of the proposed approach while Moderate Resolution Imaging Spectroradiometer (MODIS) and the High-Resolution Rapid Refresh (HRRR) are utilized as the AOD and atmospheric variables in this work. Preliminary results indicate the PM2.5 concentrations can be precisely bias-corrected to highly correlated to the FEM estimations and mitigating the sparse coverage of station data by producing the measurements based on AOD and meteorological data. This demonstrates the potential to use the proposed approach to better improve and incorporate the accuracy and spatial distribution of PM2.5 concentrations.

**Keywords:** Air Quality, Machine learning, low-cost sensor

M017 Tyson McKinney

**Micrometeorological measurements to understand water and carbon fluxes in the central Texas region**

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The Edwards Aquifer of Central Texas is the principal source of drinking water for over 2 million people in the city of San Antonio and other communities in the Texas Hill Country. This aquifer is also hydrologically connected to springs that are home to numerous federally-listed endangered or threatened species and significant cultural and recreational sites. Water budget calculations (which consider precipitation, evapotranspiration [ET], changes in vadose zone storage, and runoff) are commonly used to estimate recharge rates to the Edwards Aquifer. In this study, we use the eddy covariance (EC) technique to directly measure ET and carbon dioxide (CO2) fluxes between the land surface and atmosphere at two locations. The technique was deployed at Camp Bullis (N of San Antonio) for 2 years (between 2017 and 2019) and near Garden Ridge and Uvalde for the last 18 months. The station locations were chosen to represent processes in various vegetation assemblages that span across the recharge zone for the Edwards Aquifer. The results of these measurements will help constrain the estimates of recharge and carbon fluxes for different ecosystems surrounding San Antonio and how those values might change over time as a result of factors such as shifts in climate, forest fires, land development and other land management practices. In this poster, we will introduce the concept of eddy covariance, discuss the ongoing operation and maintenance of the stations, and present ET results

**Keywords:** Hydrogeology, Atmospheric Sciences

M018 Molly Zebker

**LAND SUBSIDENCE OVER THE DENSELY VEGETATED CARRIZO-WILCOX AQUIFER USING SPACEBORNE InSAR**

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In this study, we measure the extent and magnitude of land subsidence signals over the Carrizo-Wilcox aquifer using spaceborne Interferometric Synthetic Aperture Radar (InSAR) techniques. Here the subsidence signals are associated with withdrawal of fluids from the subsurface, either from oil and gas production or confined aquifer pumping. We processed 110 C-band Sentinel-1 SAR images from 2017-2021 over a ~100 x 200 km region near San Antonio, TX. This InSAR dataset suffers from severe decorrelation artifacts due to the presence of dense vegetation. To overcome this limitation, we use Persistent Scatterer (PS) techniques to reconstruct spatially coherent phase patterns in decorrelated interferograms, and we select the PS-interpolated interferograms with minimal phase unwrapping errors for time series analysis. Preliminary results show a region over 100 km long of up to 8 cm of cumulative line of sight (LOS) subsidence in aquifers overlaying the Eagle Ford shale, southeast of San Antonio. These InSAR results are validated using observations from GPS stations over this region with sub-centimeter accuracy. Subsidence mapping over the large-scale, complex Carrizo-Wilcox aquifer will help transform our understanding of groundwater resources and their sustainable management in central Texas.

**Keywords:** InSAR, Persistent Scatterers, surface deformation

M019 Mohammad Afzal Shadab

**Extending Richards equation to simulate variably saturated flows**

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Richards equation describes the flow of groundwater due to gravity and capillary forces in the vadose zone. But its mass conservative, saturation form degenerates when the medium saturates completely due to a singularity in the capillary pressure. Moreover, the wetting fronts in dry soils often lead to sharp spatial gradients of soil properties such as hydraulic conductivity which may cause numerical

instability.

Earlier we proposed an extended kinematic wave approximation for infiltration in soils with the

formation of saturated regions in one dimension [1]. Here we extend this formulation to propose a physics-based, multi-dimensional theory to investigate gravity-driven variably saturated flows involving complete saturation. Although the framework is developed in the limit of no capillary effects, it can be extended to include them. We also propose a suite of easy-to-implement but challenging benchmarks for variably saturation flows that lead to the formation of a saturated region. These problems are accompanied by analytic solutions which can be used for code verification, model validation and performance comparison of such simulators. Our numerical results show an excellent comparison with analytical results (and experimental data, when available).

References

[1] Shadab, M.A. and Hesse, M.A., 2022. Analysis of Gravity‐Driven Infiltration With the Development of a Saturated Region. Water Resources Research, 58(11), p.e2022WR032963.

**Keywords:** Hydrology, Infiltration, Groundwater

M020 Maximilian Ehrenfels

**Zircon ablation volume measurements using high-resolution optical interferometry, stoichiometric proxies, and x-ray computed tomography: Uncertainties and implications**

**for in-situ (U-Th)/He ages**

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(U-Th)/He thermochronometry is seeing a rapid development towards methods with high spatial resolution down to the micron scale. However, these novel in-situ laser-ablation

approaches have yet to become routine and remain underutilized as (U-Th)/He dating requires two separate analytical measurements for parent and daughter isotopes via different analytical techniques. This currently necessitates two separate laser-ablation pits and determinations of their exact volume for age dating. The accuracy and precision of these volume measurements are critical, but to date, no systematic studies have been published that quantify the accuracy and uncertainty of volume measurements and their impact on (U-Th)/He ages. We conducted systematic volume measurements of ablation-pits in polished, un-zoned, gem-quality zircon using (1) optical interferometry, (2) total signal intensity of the stoichiometric isotopes 29 Si and 96 Zr via LA-ICP-MS and (3) high-resolution x- ray Computed Tomography (CT). Common limitations in optical interferometry are the inability to image steep pit walls and interference from dust or ejecta in the pit. Stochiometric isotope proxies, commonly employed for internal ICP-MS

elemental calibration, rely on a fixed elemental concentration and constant ablation characteristics across the grain. Further problems might arise from mass fractionation on the mass spectrometer over large signal intensities and temporal changes in laser energy and ablation characteristics. High-resolution micro x-ray CT likely yields more accurate volume markers and is used to assess uncertainties in the other two methods. While the reproducibility of volume measurements by optical interferometry was ~ 3.5%, the total uncertainties were 5-10% but dramatically increased (&gt;&gt;20%) for very small diameter pits (&lt;10-micron). Volume measurements based on stochiometric intensities were surprisingly variable (10%) – a fact that is particularly significant as parent isotope concentrations cannot be measured by interferometry and are commonly determined by internal standardization. The standard error of in-situ He ages of Fish Canyon Tuff zircon confirm the magnitude of our new precision estimates and illustrate the critical need for developing improved volume measurement methods for better He ages.

**Keywords:** Thermochronology, (U-Th)/He, CT

M021 Patricia Ascanio

**Where was Cuba during the Jurassic? Insights into Cuba‚Äôs Tectonic Evolution Through a Detrital Zircon Provenance Study**

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Cuba is the largest island in the Caribbean region yet it’s role within the Caribbean region’s tectonic evolution remains enigmatic since very little has been published in English describing the island’s geologic record. However, Cuban geology is imperative to comprehend the early geological history of the Caribbean since the island hosts unique Jurassic siliciclastic units that record the early Caribbean region during the separation of Pangea and before the formation of the present Caribbean plate. These units include the Jurassic aged San Cayetano Formation located in the Guaniguanico terrane of western Cuba and the Constancia Formation found in the Placetas belt of the Central Cuban Foldbelt. Few geochronology studies each with limited sample size fail to identify the sedimentary provenance of these units, which again hampers the tectonic and palinspastic reconstructions of western and central Cuba, creating Caribbean models that oversimplify, misrepresent, or ignore the formation of Cuba. Using LA-ICP-MS analysis we implement a detailed detrital zircon (DZ) U-Pb provenance study of these Cuban siliciclastic strata which will provide critical insights into understanding the formation of the Caribbean region during the early rifting stages of Pangea. Results from 19 San Cayetano samples show a consistent Chiapas batholith (Permian-Triassic) and Grenvillian (Proterozoic) signature while 6 Constancia samples display variable Permo-Traissic and Proterozoic aged grains. By comparing this Cuban data with other regional DZ studies, we propose that that the San Cayetano and Constancia formations are correlative to the Todos Santos Formation located in the southeastern Yucatan region. These Cuban units were predominantly deposited adjacent to the Chiapas batholith during the Early Jurassic in NW-SE trending basins created by Gulf of Mexico rifting. These units were eventually detached and sheared off during eastward migration of the Caribbean plate, and laterally transported northward until collision with the North American continent in the Paleogene.

**Keywords:** geochronology, tectonics, Caribbean

M022 Noah Benitez-Nelson

**Interannual differences in the refilling of vadose zone storage drives variability in streamflow generation across seasonally dry California watersheds**

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In many seasonally dry watersheds, the water emerging from hillslopes to supply streamflow is stored in a seasonal groundwater system that is recharged by winter rains. The seasonal initiation of this recharge process is dependent on moisture deficits in the vadose zone (VZ) resulting from moisture extraction by plants during the dry season. As these deficits are replenished, incoming rains trigger recharge to groundwater systems. In this study, we conduct storage-discharge analyses across undisturbed California

watersheds to estimate the volume fraction of storm precipitation entering hillslope storage that is hydraulically connected to the stream (i.e., recharge efficiency), and thus the volume of storm precipitation required to begin refilling VZ storage. We compare these results to independent estimates of VZ storage via deficit tracking methods that rely on remotely sensed water fluxes. We test the hypothesis that differences in recharge efficiency across different watersheds reflect differences in VZ storage. Further, we hypothesize that in watersheds where VZ storage deficits vary year to year, recharge

efficiency also varies year to year. This demonstrates that interannual differences in VZ storage deficits, driven by differences in plant water availability and plant water use, impact the volume of water needed to generate runoff. While watershed gauges are sparse, deficit tracking via distributed hydrologic datasets and remotely sensed data can be applied over large scales and thus contribute to better estimation of precipitation volumes needed to generate runoff following drought.

**Keywords:** groundwater recharge, vadose zone dynamics, drought

M023 Rebekah Garza

**Deep Respiration in a Semi-arid Juniper Oak-woodland and Implications for Coupled Carbon and Water Cycling**

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In dryland ecosystems, soils can be poorly developed and roots commonly extend into weathered and fractured bedrock. Relative to soil carbon cycling processes, comparatively little is known about controls on respiration rates in the bedrock root zone. Here, we present the results of over one year of monitoring deep subsurface gas concentrations and moisture conditions in carbonate bedrock at a semi-arid woodland near Dripping Springs, Texas. At the site, soils are thin (<10 cm) or absent and roots commonly extend to greater than 3 m depth. Monitoring is established across three proximal landcover types which occur on the same bedrock, the upper Glen Rose limestone: mixed Oak (Q. fusiformis) and Juniper (J. ashei), Oak (Q. fusiformis), and grass or bare rock. Boreholes ranging from 0-9.25 m depth are used for neutron probe monitoring to document moisture storage dynamics, which occur to at least 5 m depth in the matrix and fractures of the bedrock. Trees are monitored via sap flux (24 trees) and dendrometers (4 trees). Soil CO2 efflux is measured via an infrared gas analyser that documents the rate of CO2 accumulation within a soil respiration chamber affixed to a network of permanently installed collars at the ground surface. Efflux from vegetated areas is consistently higher than collars installed over bare, fractured rock. Concentrations of CO2 and O2 are monitored in discrete ports ranging in depth from 0.08-8.8 m. The maximum CO2 concentration occurs at depths greater than 4.5 - 7.5 m, indicating persistent upward transport of CO2 across all three landcover types. O2 concentrations at these depths are greater than 13% across all depths and different moisture conditions. We find that deep respiration is occurring within the bedrock root zone and regulated in part by moisture conditions and plant activity. Accounting for these dynamics is critical for understanding land use and climate change impacts on dryland ecosystem carbon exchange. carbon cycling

**Keywords:** carbon cycling, ecohydrology, geochemistry

M024 David Keith

**Hydrologic, Geochemical, and Geophysical Characterization of an Aquifer along the Beach of a Barrier Island**

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*The University of Texas at Austin Hydrogeology Field Camp Class of 2022*

Coastal aquifers are of global importance. They nurture marine ecosystems and support billions of people living near the coast. Coastal groundwater resources are particularly important for small island communities like Mustang Island, Texas, where rising sea levels, violent storm surges, and urbanization seriously threaten the island‚Äôs aquifer. Mustang Island is a barrier island formed by sediment deposition during the last ice age. The permeable island foundation supports a small freshwater aquifer that perches atop saltwater, i.e., a freshwater lens. Freshwater lenses rely on rainfall for recharge and are susceptible to changes in sea level, including from storm surges. Consequently, freshwater lens aquifer systems frequently experience significant fluctuations in shape and extent. Here, as part of a field methods class at the University of Texas at Austin, we report the results of geophysical (electrical resistivity [ER]), geochemical, and hydraulic observations along a beach-perpendicular study transect at Port Aransas beach on Mustang Island. We mapped a water table inclined towards shore, and that changed with the tide. Our observations suggest the water table and unconfined aquifer were responding to a storm surge which occurred immediately prior to our field study. Groundwater salinity (and water electrical conductivity) increased toward the shoreline. ER imaging showed distinct zonation within the water table, measuring groundwater resistivity ranging from 2.0 - 3.6 Ohm-m between 1.5 to 3 m below the surface and groundwater resistivity of 1.1 - 1.7 Ohm-m within 1.5 m of the surface and below 3 m. Measurements of aquifer hydraulic conductivity (K) displayed distinct spatial heterogeneity, with the highest K-values measured near the shore, dunes, and 15 cm beneath the surface of the beach. The analyses of ER, geochemical, and K-value data were used to generate geochemical and geophysical models of the groundwater to better understand the evolution of the freshwater lens in the presence of a dynamic, saline tide.

**Keywords:** Hydrogeology

M025 Evan King

**The evolution of water stable isotopes through the critical zone: Direct observations from a vadose-zone monitoring system at the Eel River Critical Zone Observatory**

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Interpretation of water flowpaths through the critical zone is aided by stable isotope analysis of waters accessed from soils, groundwater, and streamflow. However, little is known about how water isotope composition evolves along flowpaths from soil to stream, particularly where the critical zone includes weathered bedrock. Here, we use novel sampling capabilities that reveal that waters transiting through a deeply weathered, steep, forested hillslope in northern California show seasonal dynamics meters beneath soils. During the long dry season, trees extract approximately 270 mm of moisture from bedrock leading to progressive seasonal drying of the weathered bedrock vadose zone to depths of 12 m. Wet season storms lead to relatively rapid wetting of the thin soils and thick weathered bedrock vadose zone to a field-capacity like state. The storms that follow are transmitted to a groundwater system at the base of the 15 m thick weathering profile, that supplies runoff to streams. To capture the evolution of water stable isotope within the hillslope, all precipitation inputs since 2012 have been sampled at daily frequency and we sample waters from discrete ~0.75 m intervals within the weathering profile via a vadose zone monitoring system (VMS). The VMS is outfitted with flexible sensors and

samplers pressed against the weathered bedrock along an inclined sleeve. Year-to-year variations in precipitation composition are transmitted within root zone waters to approximately 8 m over a seasonal timescale, but these variations may lag input by two or more years. We detect the signal of individual storm events to 4.5 m depth, including that of a deuterated water tracer experiment designed to simulate the last storm of the wet season. Even an extreme, atmospheric river event, that delivered exceptionally light water, did not perturb the deeper rock moisture composition. Consequently, water delivered to groundwater is isotopically invariant. This indicates that the weathered and fractured bedrock has a large mixing volume or rock moisture that dampens the isotopic variability of arriving waters. Samples drawn following the application of our deuterated

tracer show that mixing with residual rock moisture allows the signal to persist over multiple growing seasons despite seasonal drying of the profile. Waters cryogenically extracted from weathered bedrock samples are consistently more isotopically depleted than waters sampled from the VMS, with the exception of some saprolite samples during wet periods. We conclude that seasonal dynamics in isotopic inputs extend many meters beyond the soil into the deeper rock moisture zone, and propose that mixing of dynamic and non-dynamic water storage in the root-zone determines the water isotopic composition passed to the deeper vadose zone and groundwater.

**Keywords:** Hydrology, Vadose-zone, Water stable isotopes

M026 Cansu Demir

**Seasonal Dynamics of Groundwater Flow and Transport in the Nearshore Arctic**

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Dynamic nearshore groundwater-surface water interactions are important for the biogeochemistry and ecology of coastal waters. Groundwater flow and transport processes in equatorial to mid-latitude coastal aquifers are driven by terrestrial forcing, like regional water table gradients, and oceanic forcing such as tides and waves. In the Arctic, coastal aquifers are additionally subject to unique mechanisms which drastically change seasonally, from winter deep-freeze, to spring ice-break-up and melting, to the open-water season in summer. Moreover, little is yet known about the arctic coastal aquifers which are also likely undergoing changes due to warming. This study investigates the timing and amount of terrestrial groundwater discharge, as well as the seasonal mixing behavior of Arctic coastal groundwater ‚Äì seawater systems. We conducted field campaigns during: (1) ice break-up (June), (2) early open water (July), (3) later open water (August) and (4) freeze-up (early October) periods. The study site, located in Simpson Lagoon near Prudhoe Bay, AK, is broadly representative of shallow nearshore Arctic aquifers. Thaw depths in the nearshore area were monitored via probing of ice-rich permafrost table and multi-depth temperature measurements. Hydraulic head, salinity, temperature, and isotopic composition of groundwater and surface water were used to assess mixing behavior. Measurements were done along shore-perpendicular piezometer transects covering supra-, inter-, and sub-tidal areas across the tundra-lagoon interface. Vertical temperature profiles monitored from August to the following July indicate that inter- to sub-tidal aquifers are thermally stable from April to September. Below the bottom fast ice, groundwater flow due to thermal convection may be prominent throughout October to March, as colder temperatures were observed to overlay warmer temperatures at depth. The beach aquifer starts appearing in June and lets thawed groundwater drain through. Active layer thaw continues until early September, and freezing starts by the end of the month for fresh water-carrying sediments. Our novel findings highlight the exceptional complexity of Arctic coastal aquifers and provide insights into the physical and biogeochemical status of these systems undergoing rapid and profound changes.

**Keywords:** Hydrogeology

M027 Neelarun Mukherjee

**Supra-permafrost groundwater‚ contribution to stream flow and organic matter chemistry in the Arctic: estimation using combined mechanistic and statistical approaches**

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Seasonally warm summers in the Arctic produce supra-permafrost aquifers within the active layer. However, the magnitude of groundwater flow, the amount of dissolved carbon and nutrients, and the solute flow paths are largely unknown, but critical to quantifying downgradient contributions to surface waters (lakes and rivers). To develop approachable methods to quantify groundwater inputs in continuous permafrost watersheds, we selected Imnavait Creek watershed on the North Slope of Alaska as a representative headwater drainage. We conducted 1000 groundwater flow simulations based on topography of the watershed and varying aquifer hydraulic conductivity and saturated thickness values. We fitted a lognormal distribution to the resulting 1000 model outputs, and we derived n=1e3 possible discharge values based on Monte Carlo random sampling on the model outputs. The groundwater discharge values integrated across the watershed generally agree with observed streamflow in Imnavait Creek over 2 months. When groundwater discharge estimates were combined with in-situ measurements of groundwater dissolved organic carbon and nitrogen concentrations, we found that Imnavait Creek‚Äôs organic matter load is also dominantly sourced from groundwater. Thus, riverine, and lacustrine ecological and biogeochemical processes relate strongly to groundwater phenomena in these continuous permafrost settings. As the Arctic warms and the active layer deepens, it will become more important to understand and predict supra-permafrost aquifer dynamics.

**Keywords:** Hydrology

M028 Ebony Williams

**Multi-scale Thermal Detection of Submarine Groundwater Discharge in Critical Coastal Ecosystems of Volcanic Islands**

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Submarine groundwater discharge (SGD), or the flow of groundwater from land to sea, is an important transporter of different constituents to the coast, such as nutrients, chemicals, and dissolved metals. In volcanic regimes, groundwater might have especially high concentrations of these constituents, as it is hydrothermal in origin. One site defined by volcanic features is the Verde Island Passage, which lies within the Coral Triangle in the western Pacific. This region has been designated a marine protected area, as it is home to over thousands of different species of fish and coral reefs. Interactions of this constituent-rich groundwater with coastal waters through fractured volcanic rock can either pose a threat to or promote coastal ecosystem productivity and health. Because of this setting, it is known that SGD is a prevalent source of constituents, but how much and specifically where it is happening is unknown. Thermal Infrared Remote sensing (TIR) has gained popularity as a method of detecting SGD as it helps to resolve spatial variability issues that are inevitably accompanied by this phenomenon. Here, we investigate the use of satellite and airborne remote sensing, coupled with on the ground field measurements directly through buried thermistors and through fiber optic-distributed temperature sensing to identify and quantify submarine groundwater discharge in a coastal area of the Verde Island Passage. This study utilizes USGS Landsat 8 TIR sensor to regionally denote SGD plumes via temperature measurements of ocean water, local airborne TIR which provides finer spatial resolution than its satellite counterpart, and a 1 km-long fiber optic cable to measure temperature continuously along the coast. Results from these approaches show multiple SGD signals emanating from the coastline into the ocean and on the beach, with estimated fluxes reaching as high as 1.5 m/d and temperatures reaching up to 80°C.

**Keywords:** Submarine groundwater discharge, thermal infrared remote sensing, volcanic coastal ecosystems, distributed temperature sensing

M029 William Nguyen

**Groundwater-surface water interactions in seasonally and tidally flooded riverbanks: numerical modeling of the Meghna River, Bangladesh**

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Groundwater-influenced rivers are potential vectors for contaminant transport in areas where aquifers have high contaminant levels. For example, across South and Southeast Asia, millions have been chronically exposed to hazardous levels of arsenic (As) through drinking contaminated groundwater, but the fate of As is unknown when it reaches rivers and as groundwater and river water interact in the near-river parts of the aquifer. It is suggested that As may be stored within shallow, permeable sediments along the river-aquifer interface through sorption onto iron (Fe) (hydr)oxide surfaces, forming a permeable natural reactive barrier (PNRB). Periodic forcing represented by river stage fluctuations in these near-surface aquifers are hypothesized to influence the extent of mixing between Fe- and As-rich anoxic groundwater and oxic river water. Understanding these reactive transport processes rests on a comprehensive picture of the dynamic flow field. To achieve this, we developed a 2-D finite-element numerical model of variably-saturated subsurface flow along a transect of the aquifer adjacent to River Meghna. The boundary conditions representing the river included semi- diurnal tides, spring-neap tides, and seasonal flooding during the monsoon season. These simulations were then coupled with an aerobic respiration model to assess the potential influence of river stage fluctuations on the temporal and spatial distribution of PNRBs and eventually, As mobility. We utilized field observations of hydraulic head, sediment physical and chemical properties, and pore- water chemistry to guide and validate the model. These findings contribute to a better understanding of the hydrological and geochemical processes that impact long-term fate of As in terrestrial-aquatic interfaces.

**Keywords:** Hydrogeology, Reactive transport, Groundwater

M030 Nicholas Regier

**Stratigraphic and Structural Analysis of the Andean Eastern Precordillera, Argentina: Implications for late Paleozoic tectonic evolution of southwestern Gondwana**

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The Precordillera in the Andes of Argentina displays a complex stratigraphic record related to plate convergence along the western Gondwana margin during the late Paleozoic ice age. This study seeks to determine the competing influences of convergent margin tectonics (including subduction, terrane collision, and pre-Andean uplift) and regional glaciation (including regional erosion, sediment routing, and deposition) on basin evolution. Carboniferous deposits across the Precordillera record widespread incision and clastic infilling related to extensive glaciation.

A particularly well-exposed Paleozoic succession in the Sierra Chica de Zonda (near the city of San Juan), provides a unique perspective on the stratigraphic and structural relationships

among clastic deposits, paleo-canyon walls, and sediment source regions. Discontinuous

Carboniferous deposits (Jejenes Formation), comprised of conglomerate, sandstone, and mudstone of glacial and marine origin, fill paleo-canyons incised into Ordovician carbonates

(San Juan Formation) and Silurian clastic rocks (Rinconada Formation), characterized by sandstones, mudstones, and large olistoliths (exceeding 1,000-10,000 m 3 ). Preliminary results

from a field-based investigation of these three Paleozoic units help provide a framework for

exploring the relationships between climate and tectonics along the pre-Andean (SW Gondwanan) convergent margin during the late Paleozoic.

This study delineates the key lithofacies, depositional systems, and paleo-canyon geometries for Silurian and Carboniferous deposits. The integration of new U-Pb detrital zircon geochronology (480 grains from 4 samples) enables a reconstruction of sediment dispersal patterns in relationship to glacial erosion and tectonic deformation during deposition of the Rinconada and Jejenes Formations. These data help resolve debates over the regional tectonic setting of the Precordillera and the influence of the Late Paleozoic ice age glaciation during basin reorganization from a collisional foreland to post-orogenic extension along the western Gondwana margin.

**Keywords:** Tectonics, Sedimentology, Climate

M031 Amber Nguyen

**Is Submarine Groundwater Discharge in the Coral Triangle Higher than the Rest of the Globe?**  
*Nguyen, Amber T.*

*Cardenas, Bayani*

Coral reefs are some of the most biologically diverse habitats in the world. Not only do they house millions of species, they provide economic value to many island communities around the world through fisheries and tourism. These ecosystems are especially valuable in the Coral Triangle, an area in the western Pacific Ocean. Pollution from land through submarine groundwater discharge (SGD) is a potential threat to coral reefs. While there is an increasing amount of studies on SGD, the discharge into coral reefs is much less studied. The few studies that have been done are also very local. This research explores the global patterns of submarine groundwater discharge (SGD) and attempts to find a correlation between SGD values and coral reefs. We hypothesize that SGD values are higher in the Coral Triangle versus the rest of the world. To test this hypothesis, we will analyze previous SGD rates from other published papers through statistical analyses.

SGD data will be taken from papers published by Luijendijk et al. 2020 and Zhou et al. 2019. The SGD values from both papers will first be plotted onto a global map on QGIS for spatial visualization. Then, the SGD values will be plotted as histograms for data visualization. Lastly, a T-test and ANOVA test will be performed on the data to provide statistical differences between SGD values in the Coral Triangle versus those outside. Preliminary results from the Zhou et al. paper demonstrate, visually, that SGD values are indeed higher in the Coral Triangle than the rest of the globe. We hope to find similar results with the Luijendijk et al. paper and to further support the patterns of both datasets with statistical tests.

Future work will further explore the connected relationship between SGD and coral reefs by assigning each coral reef with a nearby SGD value (if there is one 10 km or less in radial distance.) Additionally, we will explore the spatial relationship between volcanoes and coral reefs in order to determine whether or not volcanic activity has an effect on coastal SGD. The results will indicate whether *a)* each coral reef in the Coral Triangle receives more SGD than those outside of the Coral Triangle as well as *b)* if the SGD within the Coral Triangle are more susceptible to volcanic activity. The findings will lead to further research regarding the conditions in which these coral reefs thrive and how these crucial ecosystems can be protected.

**Keywords:** submarine groundwater discharge, coral reefs, GIS, data analysis, statistics

M032 Aya Bangun

**Hydrogeochemistry of Submarine Groundwater Discharge in A Volcanic Coastal Area: Mabini Peninsula, The Philippines**

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Submarine Groundwater Discharge (SGD) delivers water and transports chemicals to the ocean. It has an essential role in the global geochemical cycle and coastal water quality. There is an increasing number of studies exploring SGD in different parts of the globe, but very few have been done in volcanic coastal areas. It is important to study SGD in this setting because volcanic coastal areas are common and these areas host environmentally and economically vital coastal ecosystems. This study examined SGD in a volcanic coastal region of the Mabini Peninsula in the Philippines, which has been noted as the center of the world’s reef biodiversity. We aim to understand the hydrogeochemistry of SGD and identify the processes behind it. We collected SGD samples at various depths, ranging from the intertidal zone to ~200 ft underwater. Our field measurements show that the springs emit warm (~50°C) acidic waters (pH ~5.5-6.5) with high dissolved CO 2 (pCO 2 ~14,000-54,000 ppm). This suggests that thermal convection driven by a volcanic heat source is a major driver of SGD in the area. The hydrogen and oxygen isotope composition of the springs, supported by chloride concentration, indicate that the spring waters are a mixture of terrestrial groundwater and recirculated seawater. Intertidal and shallow springs have a higher proportion of terrestrial groundwater (45-35%) compared to deeper springs (&lt;10%). Major ions were analyzed and plotted on a binary mixing line of the two endmembers. The plots reveal that all the spring waters show a significant shift away from the mixing line, which might imply water-rock interaction. Further investigation on the water-rock interactions will be simulated in PHREEQC and will complete the analysis of this study. Due to the similarity in geology, tectonic setting, and hydro-climatology, this study might represent many other areas in South East Asia within the Coral Triangle.

**Keywords:** SGD, hydrogeochemistry, water mixing, water-rock interaction

M033 Mohammed Fallatah

**Contemporaneous Depositional Variability in Greenhouse Mixed Siliciclastic‚ Carbonate Epeiric Seas: An Outlook from the Cretaceous (Hauterivian‚ Campanian) Inner Shelf of the Arabian Plate**

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Stratigraphic interpretations of mixed siliciclastic-carbonate systems mostly follow the reciprocal sedimentation model, which emphasizes the role of sea-level changes in controlling deposition. While this model was originally applied to narrow shelves under icehouse conditions, it remains the accepted model for interpreting the stratigraphy of broad shelves under greenhouse conditions. This study examines the Cretaceous (Hauterivian ‚Äì Campanian) siliciclastic-carbonate succession of the Arabian Plate‚Äôs inner shelf to evaluate the applicability of the reciprocal model to epeiric sea settings. Process-based sedimentology and biostratigraphy were integrated on data collected from outcrops exposed in central Saudi Arabia. Biostratigraphy yielded no diagnostic fossils or pollens for age determination. Sedimentology shows that the succession accumulated by tide-dominated depositional systems that produced six regressive (deltaic) and three transgressive (estuarine) facies associations. These are distributed in four 3rd-order depositional sequences. The deltaic successions compare well to modern tide-dominated deltas by exhibiting compound clinoform geometry; i.e. a coarsening-upward subaqueous clinoform and a fining-upward subaerial clinoform. However, the deltas here are unusual in being sand-dominated where compound dunes and pebbly sandstones are key features. This comparison with modern deltas revealed the studied succession is conformable with no major stratigraphic breaks at lithological boundaries. Alternatively, hiatuses are placed atop well-defined paleosols. This realization predicts equivalent prograding, and eventually exposed, carbonate sequences will be encountered in distal settings. The findings validate a coeval (laterally-mixed) sedimentation model rather than reciprocal for the Arabian Plate epeiric sea. This model highlights the roles of paleogeography and sediment supply in defining lateral facies changes and the resultant stratigraphic architecture. The implications of this extend to comparable greenhouse mixed depositional systems by providing a means to improve stratigraphic interpretations such that it leads to effective extraction of subsurface resources.

**Keywords:** Sedimentology

M034 Kwun Yip Fung

**Utilizing Local Climate Zone Urban Classification to Improve Tropical Cyclones Simulations in Houston**

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The Local Climate Zone (LCZ) classification scheme categorizes urban areas into ten classes to capture the urban heterogeneity for urban studies. Numerous studies have shown that incorporating LCZ in the Weather Research and Forecasting (WRF) model can lower the errors of simulated temperature, humidity, wind, and heavy precipitation. However, the effect of employing LCZ on WRF-Urban simulated tropical cyclone events has yet to be explored. We have simulated Imelda, a weak tropical storm, and Harvey, a strong hurricane that landed on Houston, Texas.

This study investigates the urban heterogeneity effect with three land use land cover experiments: MODIS in 2002 (MOD2002), MODIS in 2018 (MOD2018), and MOD2018 with LCZ (MOD2018.LCZ). Five ensemble members with different starting times are evaluated. The results from the composite average show that MOD2018.LCZ has shown lower root-mean-square error (RMSE) of wind speed in urban stations and mean absolute error (MAE) in the peak wind speed. The domain averaged cumulative rainfall has similar RMSE, but the spatially normalized precipitation shows that LCZ has captured the hot spot of rainfall in both Harvey and Imelda.

**Keywords:** Urban meteorology

M035 Cole Speed

**Tracking the spatial and temporal impact of bend cutoffs on planform migration patterns in meandering rivers: Examples from the Trinity River, Texas and Río Mamoré, Bolivia**

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Bend cutoffs in meandering rivers rapidly alter local channel geometry and flow structure, in turn modulating the planform morphology and evolution of the newly formed bend(s). Timelapse satellite imagery and field-based studies suggest the effects of cutoffs are also ‘felt’ by bends located downstream and upstream of the cutoff location. However, many questions remain concerning the distance and speed over which these effects are propagated away from the cutoff location, and whether there is variability between neck and chute-style cutoffs on the subsequent morphologic evolution of adjacent bends. Local and non-local changes in channel-bend migration behavior can impact communities established along riverbanks as well as the architecture and composition of the nearby floodplain. Therefore, developing methods for quantifying and linking the style and geometry of cutoff bend(s) to the subsequent planform evolution of the river channel – both at the site of the cutoff and away from this location – is a crucial step for successful river and floodplain management. Here, we apply a newly developed graph-based approach for measuring river planform change and 35 years of Landsat-derived channel centerlines and banks to quantify the impact of cutoff events on bends in freely meandering segments of the Trinity River, Texas and Río Mamoré, Bolivia. Specifically, we analyze spatiotemporal changes in planform bend curvature, migration rate, and transformational mode (expansion and/or translation) within individual bends both at and away from the cutoff sites. We find that, regardless of the cutoff type (chute or neck), bends produced with short wavelength and high curvature migrate more rapidly and with a significant downstream translational component when compared to longer wavelength, lower curvature bends. The Landsat-derived centerlines and a simple curvature-based kinematic model are used to further investigate how cutoff bend shape affects up- and downstream migration patterns. Our results showcase a new method for accurately measuring changes to the channel planform applied to river reaches affected by bend cutoff, which is an important step toward developing predictive models of the local and non-local impact of cutoffs on meandering rivers.

**Keywords:** Geomorphology, Stratigraphy, Earth surface processes

M036 Seungwon Chung

**An integrated framework to model regional nitrate leaching with the coupling system of Noah-MP Land Surface Model with terrestrial Carbon and Nitrogen dynamics**

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Soil nitrogen leaching is a critical indicator to address the impact of anthropogenic disturbances

on the terrestrial ecosystem and, in turn, to assess the possible degree of water quality impairment at rivers and groundwaters. Land Surface Models (LSMs) are valuable tools to understand the impacts of changes to terrestrial ecosystems on soil nitrogen leaching. A quantitative evaluation and analysis of LSM-driven nitrogen leaching are far from complete. Previous studies have used LSMs as part of Earth System Models to simulate the downstream impact of anthropogenic landscape on coastal areas at continental scales. Although the LSM can investigate the effects of regional-scale anthropogenic nitrogen inputs on water quality and water availability at extreme weather events (e.g., flooding) through nitrogen leaching, their capability as numerical weather models has not been examined.

Here, we present the regional-scale coupling of the Noah-MP Land Surface Model with terrestrial Carbon and Nitrogen dynamics (Noah-MP-CN) to address three research questions; (1) What factors do we need to understand nitrogen leaching?; (2) How does nitrogen leaching perform in long-term climatology?; (3) How does leaching perform at extreme events? The simulations are driven by the North American Land Data Assimilation System Phase 2 (NLDAS-2) atmospheric forcing for the San Antonio and Guadalupe basins in the Texas-Gulf Region. Moderate and high fertilizer application scenarios were developed using Texas Anthropogenic Nitrogen Budget (TXANB) and Net Anthropogenic Nitrogen Inputs (NANI) datasets, respectively. For the first time, this study provides the regional-scale evaluations of Noah-MP-CN-simulated nitrate leaching against Texas Water Development Board (TWDB)-observed data from 281 sites throughout San Antonio and Guadalupe Basins over 38 years (1981-2018). We show that the model can characterize spatially varying patterns in nitrate leaching. Then, we also present how

the modeled nitrogen leaching responds to extreme events, such as floods in May 2015.

**Keywords:** nitrate leaching, terrestrial nitrogen dynamics, land surface model M037 William Bailey

**Microplastics in Texas Bays**

William Bailey, Cornel Olariu, David Mohrig

Microplastics (MP), defined as plastic particles sized between 1 um and 5 mm, have become a global contaminant, reaching every continent and pose significant health risk to humans and the ecosystem. With approximately 8-14 million tons of plastic entering the oceans every year, only ca. 1% of this pollution can be quantified, signifying an immense mass balance problem. Due to the inherent density contrast between MP (ca. 0.9-1.4 g/cm3) and natural sediment (ca. 1.7-3.0 g/cm3), MPs are hydraulically equivalent to silt- and clay-sized particles, and are hypothesized to be governed by the same physical transport laws. This study aims to investigate a bay environment along the Texas Gulf Coast for microplastic pollution in order to model MP distribution and concentration in a hitherto undocumented area.

Beginning in 2021, the sampling campaign commenced, covering three large Texas bays (i.e., San Antonio, Matagorda, and East Matagorda bays), yielding approximately 150 sediment grabs and push cores located throughout the bays and adjacent shorelines. Further datasets collected include: salinity, turbidity, and bathymetry. Sediment analysis and density separation procedures are utilized to extract MP from bay sediments and map microplastic concentration and grain size within the bay environment. Using the microplastic distribution results, this study aims to: 1) define best practices and principles for MP extraction and analysis; 2) enhance our understanding of key controls governing sediment transport in bay environments with focus on MP transport and deposition; 3) understand the role of storms on bay and barrier island evolution; and 4) quantify the delivery of Colorado River sediment and MP to the Matagorda Bay.

Preliminary results from grab samples indicate the presence of microplastics in form of fibers and fragments in both San Antonio and Matagorda bay sediments. The visual inspection of the sediments accumulating behind some of the barrier islands (i.e., San Jose) along the GOM suggest bay microplastics could be sourced from the beach sands during storms rather than just from river catchments.

Future sampling campaigns will focus on identified MP concentration “hot spots” in order to understand the bay sediment dynamic and to fill current knowledge gaps in bay sedimentary processes. Results from this study (i.e., maps, methods, and transport models) will be made publicly available to promote education and awareness of the Texas (first) and global microplastic problem.

**Keywords:** Microplastic, estuary, bay, sediment transport, Texas

M038 Cole Carrabba

**Source to Sink: Tracking Tire Microplastic Pollution in Texas**

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In 2010, global plastic production was approximately 313 million metric tons (Mt), with plastic waste estimates of 274 Mt (Jambeck et al 2015). The fate of this plastic waste depends highly on the average income of the country. Middle to higher income countries more commonly contain proper infrastructure for waste disposal. One facet of plastic pollution that developed countries face is microplastics. Microplastics are a poorly understood sect of emissions that surely contribute to global plastic waste. Tires are a significant but relatively understudied source of microplastics which emit individual particles typically ranging from 5 Œºm to 220 Œºm (Grigoratos and Martini, 2014). The state of Texas contains approximately 22 million registered vehicles which drive over ~680,000 miles of roads every year (TXDOT). Using the 2020 TXDOT roadway inventory, which provides annualized traffic data (counts) and roadway segment lengths (Km), we calculated microrubber emissions values for every catalogued roadway in the state by cross. We estimate passenger vehicles (Light Duty) emit approximately 0.116 g/km of microrubber particles on average, with commercial vehicles (Heavy Duty) emitting 10x more (1.16 g/km) on average. Unsurprisingly, large metropolitan areas such as Houston, Dallas-Fort Worth, San Antonio, and Austin are pollution hotspots due to large numbers of cars and dense road networks. Our research quantifies the tire waste produced on Texas‚Äô roadways‚Äî just over 100,000 metric tons in 2020. This material is deposited by the roadsides, blown by wind, or transported by waterways. We seek a clearer picture of tire wear impact to aid future research and management of microplastic emissions.

**Keywords:** Microplastic, Pollution, Sedimentology

M040 Josiah Sananda

**Sr isotope variations in bald cypress tree rings as tracers of water quality through time in**

**Austin area streams**

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As urbanization in central Texas rapidly expands, aging and leaking infrastructure poses an

increasing threat to water quality. Our group has established strontium isotopes (expressed as the 87 Sr/ 86 Sr ratio) as effective tracers of sources of dissolved ions entering Austin-area streams. These studies indicate that urban streams in the area may contain a large fraction of municipal water under baseflow conditions due to leakage from the municipal water network. One such stream is Waller Creek, which shows the symptoms of urban stream syndrome. A significant municipal water contribution to Waller Creek streamflow is reflected in the streamwaters’ high 87 Sr/ 86 Sr values. Current historical water quality records are limited in their time span and ability to track the history and mechanisms of infrastructure failure and resulting streamwater degradation through time. This study aims to reconstruct such a time series using Sr isotope ratios in rings of bald cypress (taxodium distichum) trees; a species unique in its ability to grow in saturated riparian zones. The two endmember watersheds of interest in this study, Onion Creek (rural) and Waller Creek (urban), host bald cypress along their banks. Core samples from 21 trees in Waller Creek and 16 trees from Onion Creek watershed were collected and dated using dendrochronology. Ring width measurements from trees in these two watersheds are consistent with a significant municipal component of Waller Creek streamflow and lack thereof in Onion Creek. Waller Creek cores display homogenous ring growth through time while Onion Creek ring widths significantly decrease during drought years. We hypothesize that: 1) the chemical composition of growth rings in Waller Creek cores will reflect the increasing municipal water input into the stream over time, and 2) rural Onion Creek tree rings composition will remain consistent through time. To test these hypotheses, we develop a methodology that can analyze bald cypress cellulose with a temporal resolution of 1-5 years under low contamination conditions. This method will prepare cellulose samples for analysis of Sr isotope signatures at the desired resolution. Several methods for cellulose preparation and digestion were compared. The chosen method (ashing followed by digestion in nitric acid) was then further developed and optimized to yield low blanks and reproducible results. Blanks consistently result in less than 1 picogram (pg) Sr when analyzed using thermal ionization mass spectrometry (TIMS), allowing for sample sizes as small as 1 year of growth to be analyzed. A &lt;1 pg blank result indicates contamination below levels of instrumental detection. Method reproducibility within +/- 0.00004 was achieved for Sr isotope results, which is within the 0.01- 0.001% limitation of TIMS.

**Keywords:** dendrochemistry, Sr isotope ratios, water quality

A001 Jose Ubillus

**Experimental Investigation of CO2 Buoyant Flow Saturation in Ripple Bedforms**

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Small-scale (mm-dm) geological heterogeneities have been shown to affect CO2 saturation during plume migration, causing a substantial increase in trapped CO2 while the plume flows through the porous medium. As the CO2 plume migrates away from the injection well, and during the entire post-migration plume redistribution period, the flow regime of the plume is strongly capillary- and buoyancy-dominated. Using a 2.5D vertical sandbox flow cell, we conduct buoyancy-driven fluid flow experiments in realistic bedform architecture patterns in order to quantify the amount of CO2 trapping retainable by different degrees and types of small-scale heterogeneity under flow regimes most relevant for CO2 geologic storage. The results obtained can be used to better understand the effect of small-scale heterogeneity on capillary trapping, so in the future more accurate upscaling models can be constructed for field-scale simulation.

**Keywords:** Carbon capture, Underground Storage, Geological Heterogeneities

A002 Bella Gray

**Quantifying the Influences of Boulder Concentration on Channel Steepness in The Guadalupe Mountains, New Mexico and West Texas**

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In non-glaciated landscapes, boulders are roughness elements that alter erosion rates by acting as persistent bedrock cover and disrupting local sediment entrainment. The interplay between boulder concentration and lithologic parameters thus controls landscape morphology and response to tectonic perturbations and climatic forcings. In an attempt to quantify the influence of coarse sediment on channel steepness, this study compares the boulder concentration and normalized channel steepness along 5 major channels in the Guadalupe Mountains of New Mexico and West Texas. Normalized channel steepness here acts as a measure of stream-channel gradient normalized to drainage area and is a useful indication of erosion rate alterations in the landscape. While the data could not allow for a significant positive correlation to be identified, the methodology has broad implications in refining our understanding of how we can use satellite imagery to our advantage in remote field sites as well as working towards isolating given parameters when exploring bedrock erosion and channel evolution.

**Keywords:** geomorphology, sedimentology

A003 Shawn Fullmer

**Unveiling the Accretionary Origins of Scalloped Carbonate Platform Margins: Implications for Carbonate Platform Evolution and Demise**

*Shawn Fullmer*

*Charles Kerans*

Scalloped carbonate platform margins form some of the planet's steepest and most dramatic depositional profiles. Current understanding suggests that these profiles originate from mechanical failure and that the arcuate plan-view geometry observed represents collapse scars. We propose that an additional process shaping these margins is accretionary rather than destructive. The scalloped shape is set up by longshore-drift-generated cusps that grow seaward in a distinct quasi-rhythmic promontory-reentrant pattern. High-resolution remote sensing imagery, TanDEM-X and LiDAR elevation data, and multi-beam bathymetry data from the Lucayan Archipelago show that cuspate longshore geomorphic features and scalloped platform margins are common and have similar morphologies and geometries. The scalloped pattern originates from the deposition of longshore dominated cuspate strandplains and spits along the platform edge with focused off-platform sediment transport at the down-drift point of the cusp and decreased off-platform transport along the concavity of the cusp. This pattern persists and may be reinforced across subsequent shifts in relative sea level. Consequently, the scalloped pattern is readily observable on submerged and emergent margins. Data supporting these claims include 1) similar amplitude and wavelength dimensions of longshore cusps (n=290) and margin scallops (n=244) measured on high-resolution satellite imagery and TanDEM-X elevation data, 2) increased sediment transport at cusp tips and the down-drift terminus of longshore systems observed on multi-beam bathymetry data, 3) absence of the volume and distribution of down-slope sediment transport expected from a margin collapse mechanism. These findings have implications for understanding carbonate platform evolution and demise.

**Keywords:** Carbonates

A004 Shaunak Pandey

**Pore-Scale Simulation of CO2 Migration in Rough-Walled Geologic Fractures through Volume of Fluid Method leveraging High-Performance Computing for Risk Assessment of Carbon Sequestration**

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Over the last 150 years, the average global temperature on Earth has rapidly increased. This detrimental impact has created–among others–widespread famine, the melting of ice caps, larger, more frequent storms, drought, and poverty. Geologic carbon sequestration (GCS) involves the process of artificially injecting CO2 into underground geologic formations such as saline aquifers, enabling us to continue using fossil fuels as a source of energy while mitigating their environmental impacts, as it is unlikely that we will be able to transition to renewable energy sources overnight.

This experiment leveraged computational fluid dynamics and high-performance computing to explore the dynamics of CO2 transport and trapping in rough-walled fractures focusing on the effect of fracture geometric factors such as aperture size, roughness, and wettability.

Fractal geometry roughness was generated using a mathematical model called fractional Brownian motion (FBM), dictated by the Hurst exponent that controls the degree of roughness (fractality) in the geometry, with a higher value leading to a smoother surface. SnappyHexMesh solver was utilized to generate a hexahedral mesh in the fracture domain; coarse and fine meshing was used in order to ensure accuracy while maintaining high computational accuracy. OpenFOAM solver called interFoam was used for two-phase immiscible fluid flow simulations of CO2 and brine, through different computational nodes of the high-performance computing (HPC) system at the Texas Advanced Computing Center (TACC) at UT-Austin.

When the fracture aperture was selected to be tight, CO2 bypassed the water in the high capillary pressure zone. While for a wide water-wet fracture, CO2 tends to centrally migrate to the fracture opening and thin film of residually trapped water occurs on the surface of the fracture. Less water-wet conditions led to a larger degree of CO2 capillary trapping on the surface of the fracture. An unstable and fingering type of CO2 displacement by increasing the injection rate in a rough fracture indicates that the fracture roughness is a key factor in controlling the CO2 displacement regime in potentially fractured reservoirs. The results of this study provide novel insight of CO2 behavior in rough-walled fractures.

**Keywords**: Carbon Sequestration, Fluid Mechanics, Fractured Reservoirs

A005 Matan Lebovits

**Expanded Dimension Approach to Earthquake Detection using Convolutional Neural Networks**

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The last decade has represented a rapid increase in both the scale and sophistication of deep learning techniques. Particularly, the use of convolutional neural networks has rapidly increased in its ability to classify visually represented data. Past teams of researchers have used this to classify seismic data as either earthquakes or noise using waveform representation of seismic information in the time domain, with the intention of detecting earthquakes. Seismic waveforms are divided in time into small, discrete segments, and used to train a neural network. This has proved effective, categorizing seismic images with a high degree of accuracy. However, this data is sufficient only for one-dimensional convolutions, and may therefore be limited in its capabilities. Furthermore, the nonstationary nature of seismic data, how it varies in both the domains of space and time, is not necessarily best analyzed in a single dimension. In order to improve this, we apply a time-frequency analysis to our data, and expand the dimensions of our dataset. This serves two purposes, better representing time-space variation of seismic data, and increasing the number of parameters available to our convolution neural network. After training the neural network on a sufficiently large data set, we test its ability to classify seismic data as either noise or earthquakes, and demonstrate equivalent or greater accuracy than traditional one-dimensional approaches.

**Keywords:** Earthquake Detection, Machine Learning, Seismic Processing

A006 Jacob Margoshes

**Bathymetric and Subsurface Character of the Mississippi Submarine Canyon**

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The Mississippi Submarine Canyon is a major bathymetric feature in the northern Gulf of

Mexico off the coast of Louisiana. Submarine canyons are important routes for sediment moving from rivers and deltas across continental shelves into deepwater. We are studying the formation and evolution of the Late-Pleistocene Mississippi Canyon to improve our understanding of these processes. Formation of the canyon began around 60 thousand years ago when the Mississippi River reached the head of the canyon. Then, rising sea level cut the canyon off from Mississippi River sediments about 7 thousand years ago. Using a high-resolution bathymetry and 2- and 3-D seismic reflection data, we observed significant differences between the current seafloor expression and the subsurface character of the canyon. The bathymetry shows that the canyon currently exhibits a wide, flat bottom with both walls characterized by large slump features. The subsurface canyon, interpreted by recognizing erosional truncations and reflection terminations in the seismic data, has steeper walls, and is generally V-shaped. Multiple internal surfaces of erosion imply several periods of erosion and deposition throughout the canyon’s development. Salt diapirs observed adjacent to the walls of the canyon also may have played a role in where the canyon was routed as it was forming. Additionally, we mapped the base of the subsurface canyon using 3-D seismic reflection data. This map shows what the canyon likely looked like before it was filled with sediment. The subsurface canyon has scalloped walls similar to those of the present-day canyon, indicating that mass wasting of the canyon walls caused the canyon to widen, instead of erosional processes. Going forward, better age control of the canyon’s erosional base and studying the internal facies of the canyon will help us better understand the evolution of the canyon.

**Keywords:** Sedimentology, Stratigraphy, Quaternary Geology

A007 Kaitlin Schaible

**In situ stress within the Nankai accretionary prism determined from borehole breakouts**

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Quantifying the orientations and magnitudes of stress at tectonically active margins and along major fault systems is integral to understanding the mechanics of faulting and earthquakes. Here we use data collected as part of the Integrated Ocean Drilling Program (IODP) Nankai Trough Seismogenic Zone Experiment to constrain in-situ stress magnitudes within the Nankai accretionary prism from wellbore breakouts identified in logging while drilling (LWD) resistivity images. During drilling, concentration of stresses around the borehole wall cause breakouts to form, with widths that depend on both the rock strength and far field stress state. Using estimates of rock strength derived from p-wave velocity together with measured breakout widths, we place bounds on the far field tectonic stresses. We focus on two regions: (1) Sites C0006 and C0024, located within a few km of the trench and penetrating the plate boundary d√©collement; and (2) Sites C0004 and C0010, ~25km landward of the trench and spanning a major out of sequence thrust fault (termed the megasplay). The vertical stress (Sv) is defined by density logs, and the minimum (Shmin) and maximum (SHmax) horizontal stresses are constrained by our analysis of the breakouts.

We find that the stress state along the megasplay fault lies in a thrusting regime (SHmax > Shmin > Sv), whereas at the toe of the prism stress state is near-isotropic, with small differential stresses. Stress state remains consistent from the hanging wall to the footwall, with the exception of Site C0010 where SHmax decreases across the fault. For our best estimates of rock strength, the resolved shear stress (ùúè) on the d√©collement is 0.2 ‚Äì 0.4 MPa and the effective normal stress (œÉn‚Äô) is 7 ‚Äì 8 MPa. In order for sliding to occur along the d√©collement, assuming a friction coefficient (Œº) of 0.2, either (1) SHmax would need to increase by > 7 MPa, (2) the rock strength would need to be significantly higher than estimated, or (3) there would need to be elevated pore pressure localized along the fault. In contrast, for the megasplay, ùúè ‚âÖ 1.15 MPa and œÉn‚Äô ‚âÖ 2.6 ‚Äì 3.6 MPa. These stresses are consistent with slip on the megasplay in the current stress state, for reported frictional strength of the fault zone material (0.36 < Œº < 0.46), with the implication that the fault is near failure."

**Keywords:** subduction, geomechanics

A008 Hector Corzo-Pola

**Q-Learning for Sequential Well-Log Correlation**

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Well-log correlation matches log data from different wells to a common geologic time, removing shifts caused by spatial variations in the subsurface and allowing us to identify common petrophysical units between different locations. This can be used to extrapolate petrophysical information to larger volumes. Automatic methods for well-log correlation are preferred over manual correlations for two main reasons. The first being the inherent subjectivity of a manual correlation, and the second that manual correlations could be very time-consuming for a large number of wells.

Multiple well logs can be correlated either simultaneously or sequentially. Sequential correlation is less computationally demanding than simultaneous correlation; however, it is susceptible to error propagation and the quality of the final result depends on the order in which the logs are correlated. Unfortunately, the number of potential correlation sequences increases factorially, making an exhaustive evaluation of the quality of every possible correlation sequence unviable for large number of wells.

We propose to use Q-Learning, a model-free reinforcement learning algorithm, to identify optimal sequential correlation sequences. We provide the results of testing this approach in synthetic data and in the Teapot Dome dataset. Future work includes up-scaling this approach using Deep Q-Learning.

**Key Words:** Data matching, Well-log correlation, Reinforcement learning

A009 Katherine Garcia

**Characteristics of the Sabinetown (Wilcox Group) to Carrizo (Claiborne Group) transition**

**across the Paleocene Eocene Thermal Maximum in outcrops, Bastrop, Texas.**

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The Paleocene-Eocene Thermal Maximum (PETM) was an ~200k interval of global warming. Atmospheric pCO2 increased by 1,200 ppm in less than 10,000 years, which resulted in a global temperature increase of 5-8°C. The PETM is typically identified by a 3-5‰ decrease in global δC13 isotope values, recording a negative carbon isotope excursion (NCIE). The PETM likely impacted vegetation type and abundance, erosion, and sediment discharge, transportation, and deposition; hence examining ancient deposystems across the PETM provides a unique perspective on the potential effects of current and future anthropogenic CO 2 increase.

This ongoing study incorporates sedimentology, ichnology, biostratigraphy, bulk carbon isotope analysis, and drone photogrammetry (3D modeling and interpretation) to assess facies and stratal architecture variability in outcrops across the Sabinetown (Wilcox Group) to Carrizo (Claiborne Group) transition near Bastrop. The goals are to 1) document the paleoenvironmental evolution across the PETM, 2) identify key facies, straral architectures, and surfaces, 3) collect and analyze an expanded biostratigraphic dataset to clarify paleoenvironments and provide additional age control, and 4) identify the NCIE at the PETM.

A total of 75+ m of outcrop was measured, photographed by drone, developed into 3D outcrop models, and sampled for bulk δC13 analysis and biostratigraphy. Herein we intergrade a subset (preliminary analysis) of this data to modify and refine outcrop interpretations. In the outcrops near Bastrop, PETM is identified by a δC13 VPDB NCIE that correlates with an Apectodinium acme in a ‘dark band’ exposed intermittently below the base of the Carrizo. Outcrop δ13C VPDB isotope values range from -24.7‰ to -27.00‰, with the NCIE currently identified by values below - 26.99‰. Depositional environments across the PETM vary from distal to delta front deposits (deltaic parasequences), including mouth bars and subaqueous channels, to more proximal deposits, including channels, lignite, and potential paleosols, to large-scale trough crossbedded proximal delta front deposits, including tidal bars and channels.

Outcrops near Bastrop are important because they are easily accessible to the UT-Austin student body and provide nearby siliciclastic deposits for field courses. The Bastrop deposits are

the best exposure of the PETM interval along onshore Texas and should provide data for future

correlation to the more distal shelf and deepwater deposits. On a broader scale, examining strata that cross the PETM near Bastrop provides a unique perspective on the effects of increased atmospheric carbon and warming on coastal deposystems. This is important not only for petroleum reservoir and aquifer modeling but provides an analog for the coastal response to modern climate warming.

**Keywords:** Tidal delta, Appectodinium, Drone photogrammetry

M10 Shadya Taleb

**CO2 Migration in Saline Aquifers: A Real-Rock Microfluidic Study**

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Over the past decade, reducing carbon dioxide (CO2) emissions has become critical to tackle climate change and its impacts on human life. While several efforts are being made worldwide to reduce emission levels, geological carbon storage represents a viable technology to sequester CO2 from large-scale emission sources. However, the injection of CO2 into subsurface porous rocks is a complex process and understanding multiphase flow processes is critical for the long-term and short-term assessment of the stored CO2. This study focuses on understanding CO2 migration and trapping at the pore scale. Synthetic microfluidic models allow precise control of the pore topology; however, they fail to reproduce rock-fluid interactions and cannot capture the effects of heterogeneous mineral distribution. We use real-rock microfluidic devices made of sandstone to estimate the saturation of trapped CO2 in a brine-saturated porous medium. We first present our micromodel fabrication methodology that combines rock thin sections with nanofabrication techniques (e.g., soft lithography). Then, we obtain capillary pressure curves using fluorescence imaging and peripheral pressure measurements. Images obtained during the experiments are used to detect the phase saturation of each fluid (i.e., CO2 and brine) in the micromodel in order to quantify the fluid distributions and the CO2 sweep efficiency. These experimental results provide capillary pressure curves as a tool to predict fluid flow dynamics associated with subsurface storage operations.

**Key Words:** Geologic Carbon Storage, Microfluidics, Multiphase flow

A011 Kyle Fouke

**Assessing Complex Sea Level Instability and Environmental Change during the Last Interglacial: Insights from West Caicos, BWI**

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Careful evaluation of marine isotope records during Late Pleistocene interglacial Marine Isotope Stages (e.g., MIS 5e, 7, 9, 11) show considerable variability that could reflect climate instability. Reconstruction of MIS 5e sea level (SL) at ~129-116 ka includes a short-lived SL event documented by the presence of a major regional unconformity across the Bahamas-Turks and Caicos Archipelago (BCA). The intra-MIS 5e erosional unconformity is present across the BCA and well-documented in previous studies. However, it is not fully understood whether this unconformity was formed under subaerial or submarine conditions. The current project aims to apply next-generation sedimentologic, stratigraphic and petrographic analyses to MIS 5e marine carbonates exposed on West Caicos to: (1) determine the timing, rate, and magnitude of intra-MIS 5e SL event and (2) reconstruct paleoenvironmental conditions before, during, and after the intra- MIS 5e unconformity. The unconformity has been traced along continuous outcrops on the western coast with detailed geologic analyses at Yankee Town North, South Reef and South Point. The spatial and temporal distribution of the intra-MIS 5e unconformity has been determined using field mapping, digital terrain models, and U-Th coral dating from previously published studies. The paleoenvironmental conditions before, during, and after formation of the intra-MIS 5e unconformity were determined by vertical facies succession and lateral facies variability in addition to high-resolution brightfield and autofluorescence microscopy of depositional and diagenetic rock fabrics. Results to date suggest: (1) the erosional unconformity separates two distinct lower and upper MIS 5e reef-to-foreshore depositional systems; (2) the unconformity formed during a rapid SL fall, suggested by spatially constrained meteoric diagenesis; (3) there is a shift in lower and upper MIS 5e environmental and carbonate factory settings as suggested by vertical changes in reef communities and sediment composition. This evidence of rapid, meter- scale SL change from the intra-MIS 5e unconformity on West Caicos will be extended to reconstruct regional relative SL changes from islands across the BCA. This study and new detailed stratigraphic records of interglacial shoreline systems in the BCA are consistent with observations of climate instability, showing significant erosion and rapid (m/ky) SL change events that record both sea fall and rise events. Current models of solar insolation and global-scale ice sheet dynamics currently do not predict an intra-MIS 5e SL fall or associated sub-Milankovitch climatic fluctuations. Highlighting the magnitude and timing of an intra-MIS 5e SL fall will lead to improved numerical models that link ice sheet collapse and climate change.

**Keywords:** Last Interglacial, sea level, climate instability, Bahamas-Caicos archipelago, unconformity, carbonate diagenesis

A012 Huiwen Sun

**Effect of State Evolution Laws in Rate and State Friction for BEM-based Earthquake Cycle Models**

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Rate and state friction (RSF) laws are empirical equations describing the frictional state of the fault surface before, during and after fault slips. The evolution laws, which constitute one part of the RSF, manifest the effects of varying contact area on the frictional strength of the fault. Understanding these evolution laws is crucial for modeling earthquake cycles because they govern the complex friction memory effects and history dependence of fault frictions. Two popular models of the evolution laws, namely the aging law (Dieterich, 1979) and the slip law (Ruina, 1983) are tested using a boundary element method (BEM) based earthquake cycle model developed by Ozawa et al. (2022). The variations in rupture patterns of the simulated earthquake cycles might shed light on the nature of the two evolution laws and their effects on earthquake cycle modeling.

**Keywords:** Earthquake, Modeling, Friction

A013 Sarp Karakaya

**Generating 3D Lithology Probability Volumes using Post-Stack Inversion, Probabilistic Neural Networks, and Bayesian Classification ‚ A Case Study from the mixed carbonate-siliciclastic deposits of the Cisco Group of the Eastern Shelf of the Permian Basin, North-Central Texas**

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The deposition and mixing of carbonates and siliciclastics of the Cisco Group of the Eastern Shelf of the Permian Basin are complicated because of temporal overlap between icehouse eustatic sea-level oscillations and fluctuations in sediment influx due to the rejuvenation of the Ouachita fold belt. Numerous research on the reciprocal depositional model of the area undertaken by previous investigators used well-log correlation as the primary tool in their interpretations. However, well-log correlation alone cannot explain the system's full range of spatial lithology variations. We used an integrated approach combining wireline log information from 17 wells with 625 km2 3D seismic data through post-stack seismic inversion, probabilistic neural networks, and bayesian classification to better understand the changes in siliciclastics and carbonates facies. We used deterministic matrix inversion to derive the lithology classes from well logs. Afterwards, cross-plot analyses disclosed that Acoustic Impedance and Neutron Porosity log pair could be used to differentiate the lithologies. We performed model-based post-stack inversion to generate a P-Impedance volume and used Probabilistic Neural Networks to generate a Neutron Porosity volume. We combined these volumes through Supervised Bayesian Classification and generated lithology probability volumes for each lithology and a most probable lithology volume throughout the seismic data. These volumes revealed areas with dominant lithologies (carbonate, shale, sand, and mixed) that allowed interpretation of major carbonate platforms, sand-to-shale ratio variations, carbonate build-ups between wells, and channels' fill lithologies. The proposed semi-automated lithology detection workflow is applicable to regional studies and also valid for reservoir scale studies to determine variations in lithologies and fluid content.

A014 Braden Vines

**Glacioeustatically Driven Sea Level Fall Event within the Cretaceous Greenhouse**

*Braden Vines and Charlie Kerans*

The Cretaceous Period is commonly accepted as a greenhouse period in Earth history. During this time, Earth typically experienced high average temperatures, high sea levels, and nominal ice. However, there have been several drops in the global sea level of up to 140 meters in less than 500,000 years recognized within the Cretaceous. The magnitude and rapidity of these events as well as their global occurrences suggest glacioeustatic forcing. Additional features consistent with a glaciogenic origin for these sea level fall events are glendonites and dropstones at these intervals as well as major valley incisions. The Late Aptian substage is one of the best documented of these sea-level fall/global cooling events and is well documented in stratigraphic data from Oman, the UAE, Qatar, northern Spain, the North Sea, and the Alberta Basin of Canada. Remarkably the Late Aptian sea-level fall event has gotten little attention as an

important event in the Gulf of Mexico (GOM) or the Cretaceous shelf of Texas. Here we highlight several features, some previously know and others that have gone unrecognized, that support this Late Aptian fall in this region.

Data include field observations from across Central Texas but centralized on the Pace Band area of Lake Travis just west of Austin. where continuous outcrops of the Cow Creek Limestone and overlying Hensel Sandstone along the lake walls during present-day low-water stages reveal evidence for a 22 m deep incised valley that aligns with the globally recognized sea-level fall event. This includes using measured stratigraphic sections, publicly available LiDAR data, and 3D structure-from-motion models from UAV mapping of the Cow Creek- Hensel exposures that document the amount of erosional relief developed on the top-Cow Creek unconformity. Additionally, photo-tracing of Cow Creek and Hensel facies is used to determine the degree of post-Cow Creek, pre-Hensel erosion, which can be used to calculate a minimum value of 22 m for the late Aptian event. Further evidence to support this sea level fall interpretation includes a thick (up to 7 m) paleosol and a multi-meter deep paleokarst system developed at the top surface of the Cow Creek.

The Late Aptian cooling event that is documented in the stratigraphy of the NW Gulf of Mexico enhances the existing knowledge of this event within the Tethys Ocean. The presence of localized siliciclastic bypass associated with the top James Limestone surface reveals the potential for additional reservoir development in regional 3D seismic surveys. It is thus recommended that such surveys be revisited to understand the full extent of the Late Aptian cool snap in this important region.

A015 Richard Larson

**The Influence of Microscale Heterogeneity of Sedimentary Rocks on CO2 Migration and Capillary Trapping in Geologic Carbon Sequestration**

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Stratigraphic heterogeneities strongly control CO2 migration and its confinement in subsurface geologic carbon sequestration reservoirs. These heterogeneities can form distinct layers which express themselves at multiple different scales in geologic formations. At the pore-scale, heterogeneity is primarily controlled by the grain size in different sedimentary facies (e.g. sandstone, mudstone, shale, etc.). The contrast in grain sizes causes capillary pressure contrasts between rocks types causing CO2 local capillary trapping beneath fine-grained facies.

This study aims to leverage microfluidic experiments and numerical simulation to investigate the effect of microstructural heterogeneity on the migration and capillary trapping of CO2.

Effectively 2D, digital micromodels were created to replicate various rock facies by considering a discrete change in grain size distribution within a porous medium. These particle packing designs were then fabricated into silicon-glass microfluidic devices and CO2 injection experiments were conducted upon them. Using the experimental data, we extracted CO2 migration patterns, saturations, and the capillary entry pressures of combinations of facies. We then quantified how these properties depend on the grain-size contrast among facies. The experimental results were utilized as calibration of pore-scale two phase flow simulation capable of predicting CO2 flow dynamics and subsequent trapping in different microstructural geometries and under various boundary conditions.

Numerical simulations using computational fluid dynamics to model these same geometries were also conducted. When validated to these initial patterns, these can then be applied to 3D pore networks and can be used to predict CO2 behavior in different pore structures and under various boundary conditions without the need for physical experiments. The aim of this study is to dictate how dominant the existence of these structures is on the long-term fate of subsurface CO2 plumes in large-scale CO2 injection projects.

A016 Shuang Gao

**Fractal-based carbonate seismic characterization**

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We use multiscale seismic data interpretation techniques to characterize carbonate structures deep in the subsurface, i.e. karsted fault and fracture structures. Carbonate formation with high seismic velocities features lower horizontal and vertical resolution, and incorporate complex heterogeneities at different scales. To delineate multiscale geologic structures from seismic data, reflection and diffraction data are jointly analyzed, and fractal basis decomposition are applied.

**Key Words:** carbonate, deep learning, seismic interpretation

A018 Ben Gremillion

**Elastic seismic imaging of a fracture with time-lapse DAS VSP**

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We investigate the feasibility of imaging a single fluid-filled fracture using time-lapse distributed acoustic sensing (DAS) for vertical seismic profiling (VSP). We incorporate field experiments from the Devine Field Pilot Site, effective medium modeling, and elastic imaging of synthetic data to determine how to most accurately image the fracture and estimate its scattering potential. Our results show that the strength of the fracture‚Äôs scattering response is highly dependent on source bandwidth and P-to-S wave reflections are more effective than P-to-P wave reflections for imaging the fracture with the given DAS acquisition.

**Keywords:** fractures, elastic seismic imaging, DAS

A019 Rawan Alasad

**Alluvial fan and fan delta facies architecture recording initial marine flooding in the Mio-Pliocene syn-rift sequence of the Fish Creek-Vallecito Basin, southern California**

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The timing and character of the initial marine flooding of extensional basins has implications on their tectonic history. Yet, the recognition of such flooding is difficult in proximal extensional basins due the dominance of coarse-grained systems and the lack of marine fauna. This study conducts detailed facies and stratigraphic analysis of a Mio-Pliocene alluvial fan and fan-delta succession in the Fish Creek Vallecito Basin in southern California. The goal is to determine the paleo-geographic position of the shoreline, estimate the magnitude of sea-level rise that occurred during the marine incursion associated with the opening of the Gulf of California, and constrain the tectonic history of the basin. Our results show that the flooding of the alluvial fans is often marked by an abrupt lithologic and facies change from meter-scale boulder-rich subaerial debris flows to centimeter-scale granule-rich subaqueous sandy debris flows suggesting abrupt rather than gradual retrogradation of the fans during the marine flooding. By mapping the zone of transition between the subaerial and subaqueous facies, we place the paleo-shoreline 4 km up the Elephant Tree alluvial fan paleo-depositional slope. This 4 km transgression would require an estimated 70-350 m of relative sea-level rise during the initial marine incursion. This high magnitude and abrupt relative sea-level rise can be explained by deposition in a subaerial sub-sea-level basin like Death Valley and the Salton Trough today. The deposition of the planktonic-rich Fish Creek Gypsum on the distal toes of the fan-delta further supports a sub-sea-level and hydrographically restricted marine basin that was abruptly flooded to neritic depths. The tectonic history of the FCV Basin maybe similar to other extensional basins where rapid subsidence allows the accumulation of continental strata below sea-level prior to marine flooding, then deep and restricted marine strata immediately after the flooding.

**Key Words:** Sedimentology, Stratigraphy, Basin Analysis

A020 Caroline Mackin

**Paleoenvironmental Analysis on A Core Collected Offshore Galveston Bay to Reconstruct the Trinity River Paleovalley**

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From the Last Glacial Maximum around 20 ka until the Holocene, sea level on the Texas Gulf Coast rose rapidly. The rate of sea level rise reduced over the late Holocene and then increased again in the 20th century. With fluctuating sea levels and storm patterns, the Texas Gulf Coast may be increasingly susceptible to coastal erosion. There is a need for beach nourishment and other coastal restoration projects in response to these effects. We investigate the Trinity River Paleovalley, offshore of Galveston, Texas, to determine the long-term stability of estuarine environments. Analysis of sediment cores taken from the area provides records of paleoenvironmental change in the estuary filling the drowned river valley. These cores also indicate the location of fluvial sand deposits, (e.g., point bars) which are opportune sources of sediment for surge barrier construction and other nourishment projects. With funding from the Bureau of Ocean and Energy Management and the Texas General Land Office, a multi-year study is ongoing to construct the Trinity River paleovalley through analysis of chirp sub bottom data, magnetic susceptibility, biostratigraphic analysis, carbon-dated macrofauna, and foraminifera population counts. Here we show data from a new core that is of particular interest to this study because it targets an expanded estuarine interval based on chirp seismic data, landward of our previous cores. The lowermost 3 m of the core has a silty clay composition and contains vegetative organic matter, but there is no presence of foraminifera which suggests that the lower part of the sample is a bay marginal environment or a seagrass bed. The uppermost 2.8 m has a silty mud composition that contains oysters scattered throughout which likely represents a middle bay environment. At ~3 mbsf, ammonia foraminifera make up approximately 98% of the genera present, but this percentage reduces to 93% up-section in the core. These data indicate a rise in sea level and a shift in the estuarine environment from the central bay to the bay mouth over the time represented by this core. Ongoing investigations of other cores in the area will help us better understand environmental variability across the middle to late Holocene Trinity River estuary.

**Key Words:** Foraminifera, Galveston Bay, Holocene Sea Level

A021 Fernando Rey

**Using Lu-Hf in detrital zircon to follow the extension of a Back-arc basin: an example from the**

**Jurassic-Cretaceous Rocas Verdes Basin in southernmost Patagonia**

*Fernando Rey and Matthew Malkowski*

Back-arc basins (BABs) are extensional environments formed in the back-arc region of

convergent plate margins where rifting, and possibly seafloor spreading, develop on the

overriding plate. BABs occupy a sizable fraction of the modern Pacific plate margin and have

likely occupied much more of the Pacific margin in deep time. A common approach to

determine the onset of BAB extension is to date the onset of bimodal volcanism. However, the

study of ancient BABs is commonly challenged by an incomplete rock record due to

deformation and erosion during the basin&#39;s closure and subduction/accretion. This adds a

preservation bias that obfuscates our ability to determine the correct timing for the onset of

extension. This study aims to ameliorate this bias using combined U-Pb and Lu-Hf isotopes of

detrital zircons to determine the timing of the mantle upwelling and crustal extension. We

hypothesize that an inflection in the Lu-Hf isotopes toward higher eHf(t) values accompanies

the initiation of back-arc extension and thus provides a useful supplement to measuring the U-

Pb age of bimodal volcanism. We assume an increase in eHf(t) signals the onset of juvenile

magmas associated with mantle upwelling and extensional tectonism.

The Jurassic-Cretaceous Rocas Verdes Basin in southern Patagonia is a well-known

ancient BAB that opened diachronously from South to North during the Middle to Late

Jurassic. We collected sandstone and river sand samples from two study areas along the N-S

axis of the basin, separated by 200 km. In the northern samples (n=227), the Lu-Hf content

show a positive trend at 157.4 +/- 1.5 Ma, while in the southern samples (n=59) the positive

trend appears earlier, at 176.7 +/- 1.5 Ma. The relative timing of positive EHF(t) trends is

consistent with the diachronous initiation of extension but suggests older initiation ages than

those previously determined by dating bimodal volcanism (154.5 +/1.2 Ma in the North and

171.8 +/-1.2 in the South). These preliminary results suggest that combined U-Pb and Lu-Hf in

zircon may improve, or at least provide additional information for, the timing of the

geodynamic phases of BABs. Future work will be aimed at expanding this dataset to determine

the timing of the extensional stage for the complete outcrop extent of the basin.

A022 Mingang Hao

**Cretaceous Uplift and Evolution across the Gangdese Magmatic Arc System in Southern Tibet**

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The east-west trending Gangdese magmatic arc was one of the most predominant topographic features located at the southern margin of Tibet before the arrival of the Indian plate. However, the detailed Cretaceous growth and evolution across the arc system remain ambiguous. The adjacent Xigaze forearc basin provides a well- preserved and well-exposed record of the tectonic and magmatic evolution of the arc throughout the Cretaceous. Here we report new stratigraphic, sedimentological, geochronological, and provenance analyses of the Quarry Ridge in the Xigaze forearc basin along with a total of 13062 zircon age (n=9674) and Hf signature (n=3389) compiled data from the Gangdese arc and associated forearc basin and retroarc foreland basin to determine the early to middle Cretaceous uplift of the Gangdese arc and discuss concurrent sedimentary responses within basins. Exhumation of the arc was initially documented at around 113 Ma suggested by arc detritus first arriving in both basins; Another at around 108 Ma that resulted in coarse-grained sedimentation in adjacent basins and preventing central Lhasa source from reaching the Xigaze forearc basin further south; And finally a third episode at around 100 Ma which is reflected by deposition of the progradational Quarry ridge classic succession and marks the initiation of substantial coarse- grained deposition in the Xigaze forearc basin. Magmatism, crust thickening, and activity of the Gangdese retroarc thrust belt contribute to the uplift and exhumation of the Gangdese arc. Our study provides an orogen-scale assessment of the history of arc magmatism, uplift, and sedimentation across the Gangdese magmatic arc system and supports interpretations that Tibet was characterized by complex and substantial topographic relief during the Cretaceous before the collision between the Indian and Eurasian plates.

**Keywords:** Growth of Tibet, Gangdese magmatic arc, Xigaze forearc basin, Linzhou foreland basin, Paleogeography, Sediment provenance, Cretaceous

A023 Esha Krishnan

**Decoupling Provenance and Weathering: Testing Decoupling Techniques on Silicate Weathering**

**Profiles**

*Krishnan, Esha S.*

*Malkowski, Matthew A.*

*Rey, Fernando M.*

Siliciclastic sediment and sedimentary rocks are derived from the physical and chemical breakdown of their parent material. Thus, sediment composition is controlled by both the type of rock (provenance) and rock-fluid interactions (weathering). By tracking and separating these changes in provenance and weathering in fine-grained sedimentary rocks, these components can be used to interpret the history of their parent material. One technique developed by Lipp et al. (2020) uses a series of statistical analyses to produce a model that decouples these signals. Using a centered log-ratio transformation and a principal component analysis, Lipp et al. plotted weathering and provenance signals against the depth of a rock-soil profile. The basis of the model requires the usage of two endmember scenarios: constant provenance and change in weathering, and constant weathering with change in provenance. Using these two as the

weathering and provenance axis’ respectively, additional profiles added to the plot compare the relative differences in geochemical signals. However, as the weathering axis is set to different constant- provenance lithologies, the results change. The slopes of the constant-provenance profiles change with the alteration of the weathering axis due to the nature of the principal component analysis (PCA). We seek to test the hypothesis that PCA significantly distorts the graphical visualization of the profiles, potentially affecting geologic interpretation. Future work aims to test other dimensionality reduction techniques, such as multidimensional scaling, to reduce the observed graphical variance.

**Keywords**: Silicate weathering, weathering profiles, sediment geochemistry, statistical analysis, machine learning, compositional data analysis.

A024 Jacqueline Epperson

**The Use of Detrital Zircon Maximum Depositional Ages Through the Lens of an Arc- Unroofing Sequence, Great Valley Group, California**

*Jacqueline J. Epperson, Matthew A. Malkowski*

The continuously increasing application of detrital geochronology has been paralleled by growing interest in using the maximum depositional age (MDA) to constrain the depositional age of sedimentary units. The efficacy of using a deposit’s MDA to constrain its true deposition age (TDA) is contingent on the deposit having contemporaneous (e.g., volcanic) zircon. However, applications of using a deposit’s MDA to constrain its TDA rarely consider the specific nature of arc-derived sediment (i.e. plutonic versus volcanic). We seek to test the hypothesis that the efficacy of utilizing the MDA as the TDA is contingent on the deposit’s relative influence of undissected vs dissected arc provenance. To test this hypothesis, we will evaluate detrital populations from the classic arc-unroofing sequence of the Great Valley Group in central California, as well as modern sediments from central California. Sandstone compositions from the Great Valley Group and modern California reveal a temporal and spatial transition from undissected to dissected arc sediment shedding (Ingersoll 1983, Ingersoll et al 2007), making it an ideal study area to evaluate our hypothesis.

Preliminary results from compiled data of the Great Valley Group(Surpless et al 2002, Orme et al 2019, Wright and Wyld 2007) show that each stratigraphic unit has both an increase in the relative contribution of dissected arc sediment and in the lag time between MDA and TDA from oldest to youngest geologic formation. We hypothesize that this trend in the MDA/TDA divergence and relative contribution of dissected arc input is influenced by not only the abundance of contemporaneous zircon, but also a bias in grain size and fertility between plutonic (dissected) and volcanic (undissected) zircon sources. This bias in zircon fertility is confirmed by volumetric measurements of zircon per sample, and shows the correlation between increasing dissected source input and zircon abundance. Zircon size and shape has also been characterized by CT scanning and 3D analysis via the Blob3D application, which analyzed the samples for volume, surface area, and sphericity. (Ketchum et al. 2005).

Results of this work will elucidate the controls on the geological conditions best suited for MDA applications. Moreover, the results aim to quantify the relative composition and contributions of arc sources needed to yield an MDA that tightly constrains a deposit's age.

A025 Raymond Luong

**Evaluating age and grain size relationships in Detrital Zircon Grains**

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Detrital zircons are widely used for U-Pb age dating, which is an important fingerprinting tool for studying the provenance of sediment. Traditionally, zircon grains are chosen and dated using a random selection procedure to provide a representative and unbiased suite of ages from a sample. However, little is known about the characteristics of the zircon grain sizes, such as how a natural bias in grain size and U-Pb age could arise due to hydrodynamic separation. In the San Francisco Bay area, sand samples from Suisun Bay and Central Bay are interpreted to have different provenance signatures. However, these signatures may be influenced by a potential grain size difference between the two locations, since the Central Bay sediment is coarser grained. This provenance distinction has important implications for the sustainability of sand mining in the region. We hypothesize that there is a correlated bias between detrital zircon sizes and U-Pb ages, which affects the age distribution, and therefore provenance interpretations of the sample. To test for this grain size bias, zircon grains were imaged with reflected light and then manually traced to be used as training data for a convolutional neural network with a Unet architecture. Once the machine learning model is trained, it allows us to characterize the size and shape of the grains and match with the corresponding U-Pb ages to evaluate age-size relationships. In the future, this two dimensional data can be compared with the ages and sizes of grains determined three dimensionally to test the accuracy of two dimensional analysis and would better constrain the accuracy of provenance research.

**Key Words:** machine learning, U-Pb, detrital zircon

A026 Anurag Kulkarni

**Mudstone Geochemistry as an Indicator of Provenance in an Arc-Unroofing Sequence**

*Anurag Kulkarni, Matthew Malkowski, Jacqueline Epperson*

Due to their formation at subduction zones, forearc basins preserve integrated records of

magmatic arc unroofing in their stratigraphy. These records are commonly studied using the

coarse-grained fraction of forearc basin fills, often neglecting the more abundant finer-grained

mudstone fraction. Geochemical analysis of mudstone can be used to identify the presence of

unstable mafic minerals and volcanics and provide a more homogenized provenance signature.

Measurement of major elements Ti-Al/Fe-Mg and trace elements V-Sc/Th\*10 are useful provenance indicators with a specificity on the transition from mafic to felsic sources during arc

exhumation. Geochemical data also provides a supplement to provenance results derived from

interpretation of sandstone petrography and U-Pb detrital zircon analysis that is limited to coarser-grained and felsic to intermediate sources.

The Great Valley forearc basin in central California is an excellent example of remnant forearc basin stratigraphy and has been well studied utilizing U-Pb detrital zircon analysis, sandstone composition, and to some extent mudstone proxies (Ingersoll 1983, Surpless et al 2002, Surpless et al., 2014; Orme et al 2019). Since the Great Valley Group contains sediment from the dissection of the Sierra Nevada arc, we hypothesize that geochemical signatures of unstable mafic minerals and volcanics should decrease over time as the volcanic arc composed of mafic to intermediate volcanic rock is eroded and the more intermediate to felsic Sierra Nevada batholiths of today are exhumed.

To test our hypothesis, we will analyze the major and trace element geochemistry of the

mudstone that makes up a significant amount of the Great Valley Group. The Cortina, Boxer,

Lodoga, and Stony Creek stratigraphic units of the Great Valley Group all contain large amounts

of mudstone that is largely unstudied. Knowing that zircon analysis is biased toward felsic plutonic sources of the Sierra Nevada arc, geochemical analysis of the mudstone in these units

may be able to serve as an important supplement to zircon analysis derived from coarse grained

beds. We aim to achieve a higher resolution of data than previous studies by sampling at 1-meter intervals from these four stratigraphic units. This higher sample resolution provides a more detailed picture of provenance trends in the mudstone geochemistry.

A027 Jana Alabdullatif

**Spatial Quantitative Analysis of Modern Compound Clinoforms**

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*Ronald Steel, University of Texas at Austin*

Compound delta clinoforms have long been recognized in modern systems, where they exhibit an interplay between shoreline and subaqueous clinoforms that uniquely respond to different oceanographic energy regimes. While their morphology is noticeable in modern systems, little effort has been dedicated to identify and delineate their intricate spatial morphological variability. This study aims to establish a foundational spatial understanding of compound clinoforms development and morphology through quantitatively analyzing high-resolution global bathymetry data of modern deltaic systems. Results on compound clinoforms show commonalities in morphologic and spatial variability away from the sediment source that are linked to oceanographic energy regimes, and unique signatures connected to the basin configuration of each delta. This work anchors our understanding of sediment transport in shallow marine systems, river deltas, and adjacent shelves, and facilitates reinterpretation of ancient systems. Consequently, this study has direct industry implications in expanding hydrocarbon reserves, increasing CO2 sequestration potential, and quantitatively improving facies models for reservoir characterization.

**Keywords:** Delta, Clinoform, Clastic Sedimentology

A029 Edward Clennett

**Palaeogeography of the Miocene Iranian Plateau**

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Plate reconstruction models are widely used in a number of different fields: they are important input models for climate and oceanographic simulations, help assess the occurrence of natural resource deposits, and are used in palaeontology and palaeogeography studies. Recent plate models have progressed beyond the rigid plate theory to include continental deformation, in regions such as the Arabia-Eurasia collision belt. Such deforming plate models are typically constrained with geological cross sections or palaeomagnetism, but without consideration of crustal thickness changes. Using a high-resolution crustal thickness compilation, I restore crustal thickness and topography back in time over the past 25 Myrs to create a palaeogeographic map of the Miocene Iranian Plateau. This palaeogeography is then compared with stratigraphic studies of paleo-environments, which provides a independent test of the validity of the plate reconstruction. The observed poor fit shows that existing plate reconstructions do not realistically model the deformation that occurs during the Arabia-Eurasia collision, and need improving. Thus, in future work, I will incorporate additional evidence from seismic waveform and crustal thickness inversions to improve deforming models of the Arabia-Eurasia Collision.

**Key Words:** Tectonics, Geophysics

A030 Morgan Carrington

**Geomorphic processes for forming amphitheater-headed canyons on Earth and Mars**

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Amphitheater-headed canyons are river valleys that initiate at deeply entrenched canyon heads, with steep walls and curved (i.e., amphitheater-like) planforms. These landforms are commonly observed in valley-networks on Mars and within river systems on Earth. Previous studies have proposed their formation to be the result of groundwater sapping processes and/or precipitation- based runoff, but the role that these formation mechanisms play, especially in relation to groundwater flow on Mars, is still highly debated.

Here, I will present preliminary work on a project aimed at helping to constrain the role groundwater sapping and surface runoff play in the formation of amphitheater-headed canyons utilizing Mars-based analysis and Earth analog components. My work on Mars will target amphitheater-head canyons in multiple distinct regions. Measurements will include (1) estimation of regional groundwater paths surrounding observed canyons using existing topographic data; (2) quantification of the contribution of potential surface run-off by looking upstream of the main canyon heads to identify channels that lead into canyons downstream, and (3) quantification of channel characteristics (e.g., drainage area, channel width, etc.) across regions, particularly looking at the ratio between drainage area and retreat of canyon heads. The results from these measurements will then be used to design a comparative field campaign for amphitheater-headed canyons in the Henry Mountains of southeast Utah, where remote-sensing data and field work methods will further our understanding of what role groundwater plays in carving the canyons observed on Earth, and by analogy Mars. Determining the role that the proposed processes play on canyon formation has important implications for constraining the duration of surface water activity on Mars, specifically whether that activity was limited to the valley-network forming era or extended beyond it.

**Key words:** Mars, rivers, geomorphology

A031 Michelle Tebolt

**Characterizing the Facies and Stratigraphy of the Enchanted Lake Outcrop in Jezero Crater, Mars.**

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*Kathryn Stack Morgan, Jet Propulsion Laboratory*

*Sanjeev Gupta, Imperial College London*

*Robert Barnes, Imperial College London*

Jezero crater once hosted an open lake system ~3.8 Ga when water is considered to have been abundant on the surface of Mars. A sedimentary delta deposit formed at the western rim of the crater and remains well-preserved on the surface today. Studying the stratigraphy of the Jezero delta can be used to better constrain the fluvial and climate history of early Mars.

Here we present analysis of the Enchanted Lake outcrop, which is located on the eroded southern margin of the delta deposit. This outcrop was the Mars 2020 *Perseverance* rover’s first direct encounter with sedimentary rocks at the base of the delta deposit. Data of this outcrop were first collected from sols ~420-426 of the *Perseverance* mission. The rover then traversed to the northeast to explore the Hawksbill Gap area before returning to Enchanted Lake for sols ~565-600. This study identifies and characterizes the facies within the Enchanted Lake sedimentary succession and interprets the paleoenvironment of the outcrop in context with the larger deltaic system.

We identified outcrop using images taken by the Navcam, Mastcam-Z, and SuperCam’s RMI camera systems onboard Perseverance, and used these data to define facies and relative stratigraphic position. Facies were distinguished using physical lithologic differences, specifically grain size, bedding/lamination scale and type, degree of erosion/weathering, and sedimentary structures. From stratigraphic lowest to highest the identified facies are: low angle cross stratified medium sandstone, curvilinear laminated sandstone, planar thinly laminated siltstone, recessively weathered siltstone, and coarse-grained sandstone.

We interpret this outcrop as a turbidite, part of an unconfined, submarine fan lobe, formed when a subaqueous gravity flow traveled down the slope of the delta and deposited sediment distally on the lake floor. The facies observed at Enchanted Lake are consistent with portions of a Bouma sequence, the classic presentation of turbidite facies. This includes cross-stratified and convoluted laminations, parallel laminae, and hemipelagic sediment. While the Enchanted Lake outcrop does not preserve a full Bouma sequence, it is uncommon to find a fully intact Bouma sequence in nature, and partial sequences are much more common.

Some of the facies present in Enchanted Lake are also consistent with what might be expected for a fluvial or beach margin setting. However, the rocks at Enchanted Lake are missing abundant cross-stratification (e.g., ripples and/or dunes), which are typical features of channelized fluvial sediment bodies. Due to this lack of cross-stratification and any other features to indicate subaerial exposure (e.g., mudcracks), we suggest the outcrop facies are most consistent with subaqueous unconfined gravity flows (i.e., a turbidite). As an unconfined distal deposit, Enchanted Lake would represent part of the delta system building out as bottomsets.

**Keywords:** Planetary Science, Stratigraphy, Sedimentology

A032 Soraya Alfred

**Investigating How the Post Impact Hydrothermal System Affected Stratigraphy Beneath the Chicxulub Crater**

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The 200 km wide Chicxulub impact is most famous for bringing an end to the Cretaceous period as well as having the most well-preserved peak ring structures on Earth, with a central basin measuring 65 km in diameter. As expected with an event of such massive scale, large amounts of heat were delivered to the target rocks resulting in an ~2.5 km melt sheet underlying the central basin. This melt sheet is overlain by ~400 m of melt bearing breccia (called suevite) which hosted a prolonged post-impact hydrothermal system. The duration of this system is still being debated but is believed to be on the order of millions of years. Seismic reflection images that served as site survey data for the International Ocean Discovery Program (IODP) Expedition 364 show melt upflow zones, specifically along the CHIX9 and CHIX10 seismic lines. These characteristics are unique in the fact that they disrupt the overlying sedimentary layers at the Paleocene/ Eocene boundary. This suggests that the features could be as young as 11 Myr, indicating that the mechanism which triggered their development came into effect long after the original impact event. We hypothesize that these upflow zones are the result of the hydrothermal system. We propose to model the post- impact hydrothermal system to determine if it is possible to produce such features while ground truthing the model with the Expedition 364 drilling data from the peak ring and new 3D seismic data collected over the peak ring and central basin regions of the impact structure.

Currently the origin of the upflow zones is not clear. I am planning to investigate several possible physical mechanisms: Diapirism of the suevite due to sediment loading, alteration due to hydrothermal convection, gas chimneys or fluid escape pipes and other processes. These mechanisms can be compared to the observed wavelength and timing of the upflow structures. This may provide constraints on critical physical properties of the suevite during the period when the hydrothermal system was active.

Successfully recreating the scenario that led to the presently observed stratigraphy of the Chicxulub impact structure can give us great insight into the evolution of the hydrothermal system and hence provide a more in-depth idea of the role it played in the recovery of life after the impact. By extension, understanding the evolution of impact hydrothermal habitats can inform discussions of these settings for the prebiotic to biotic transitions on Earth or elsewhere.

**Keywords**: hydrothermal convection, numerical modelling, impact crater, seismology

A033 Mariel Nelson

**Controls on river bank erosion timing and meander bend evolution using time-lapse lidar of the Trinity River in Texas**

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Earth‚Äôs big rivers can erode their banks at a rate of several meters per year, modifying channel width and changing the planform shape of channel bends. The processes controlling when and how river banks erode are difficult to quantify because precise, repeat survey data of steep bank topography is hard to collect at the bend scale. To map bank erosion along two bends of the sand-bedded, 150 m wide Trinity River near Dayton, Texas, USA, we use lidar surveying equipment mounted on an uncrewed aerial vehicle (UAV). Here we will present monthly lidar topography data collected beginning in April 2022 and hourly photos of the channel banks taken with trail cameras. The surveyed bends have been mapped with airborne lidar in 2011, 2015, and 2018 and the river is instrumented with a USGS gage (08067000) 17 km downstream. We processed and differenced available lidar datasets (airborne and UAV) to examine how the river bank topography has changed over time for comparison with the gage data. From January 2018 to June 2022, we mapped between 0 and 18 m of lateral bank retreat along the two surveyed bends and computed an average erosion rate of 1.75 m/year, which is below the calculated long-term average erosion rate 4 m/year. The two point bars opposite the eroding outer banks of both bends show changes in surface elevation of up to ¬± 2 m, with both bars generally eroding on their upstream ends and aggrading on their downstream ends. We mapped minimal change in the channel banks between the April to July 2022 surveys, which captured notably dry months. However, we also present results from continued surveys through fall 2022, which may yield measurable change. Lastly, we compared mapped erosion patterns with a curvature-based model for river bend migration. This high-resolution (in time and space) dataset of river bank evolution will help determine when distinct channel bank erosion processes dominate‚Äîe.g., landsliding versus progressive hydraulic abrasion from the river. This project also provides a set of time-lapse data documenting the evolution of channel bank geometry, which can be used to test existing models of alluvial channel bank erosion timing.

**Key Words:** geomorphology, remote sensing, hydrology

A034 Juan Vazquez

**Examining Bend Asymmetry of Sinuous Lava Channels Across the Lunar Surface**

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Sinuous channel-forms are present throughout the entirety of the Solar System and are formed via supraglacial, fluvial, and volcanic activity. Despite having many similarities, there has been little work done to assess the geometric similarities of the planforms between channel-forms created by different processes. This study aims to provide preliminary results on the first observational analysis of whether channel-form sinuosity has distinct patterns in bend asymmetry across the Moon, Venus, and Earth, depending on its formation mechanisms. Our approach involves using satellite images to map out channel-forms in the ArcMap GIS software, followed by planned analyses of channel-form bend asymmetry. Initial analyses have begun on Lunar sinuous rilles using images taken by the SELENE (Kaguya) spacecraft. Lunar sinuous rilles are mostly formed via volcanic activity and thermal erosion, and are found across the entirety of the Lunar surface. The rilles analyzed have average widths ranging from 500 meters to 15,000 meters and are part of an initial sample size of 10 rilles. For each analyzed rille we mapped channel edges, distinguishing between between certain and interpolated edges, then converted that to a centerline via a series of geoprocessing steps. Ongoing work includes tracing outlines of more sinuous rilles to then extract centerlines to quantify asymmetry, with future planned work to compare these results with river channels and supraglacial channels on Earth, and sinuous lava channels on Venus.

Keywords: Moon, sinuous channels, lava channels, remote sensing

A035 George Segee-Wright

**Controls on the Halogen Content of Nominally Anhydrous Minerals in Variably Metasomatized North American Sub-Continental Lithospheric Mantle Xenoliths**

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*John C. Lassiter, University of Texas at Austin*

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*Veronique Le Roux, Woods Hole Oceanographic Institution*

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Flat-slab subduction of the Farallon plate metasomatized the North American sub-continental

lithospheric mantle (SCLM), enriching it in halogens (F, Cl, Br, I). However, the extent to which

metasomatism enriched nominally anhydrous minerals (NAM) in halogens remains unclear. To

constrain NAM halogen enrichment, we examined the F, Cl, and H 2 O contents of clinopyroxene

(cpx), orthopyroxene (opx), and olivine (olv) in modally hydrated peridotite xenoliths from the

Navajo Volcanic Field (NVF; Colorado Plateau) and anhydrous xenoliths from Cerro Chato

(Colorado Plateau margin), Kilbourne Hole (Rio Grande Rift), and Elephant Butte (Rio Grande

Rift).

Xenoliths from all suites have similar ranges of water contents (50-500 ppm in cpx, 30-280 ppm

in opx, 3-30 ppm in olv). However, NVF xenoliths have slightly higher Cl contents (0.1-1.5 ppm

in cpx) and lower F contents (&lt;0.1-3 ppm in cpx) than the anhydrous xenolith suites ([Cl]=0.1-

0.2 ppm in cpx; [F]=16-75 ppm in cpx). Transects across two cpx grains with elevated Cl

contents show a systematic increase in Cl from core to rim. Transects of grains with lower Cl

contents show no variation from core to rim. Elevated [Cl] but low [F] in NVF xenoliths is

consistent with the metasomatism of melt-depleted SCLM by a slab-derived hydrous fluid with

elevated Cl but little F. Additionally, both Cl and H 2 O correlate negatively with olivine oxygen

isotope ratios, consistent with Cl enrichment of the lithospheric mantle via an aqueous fluid.

However, NAM [Cl] does not correlate with bulk xenolith [Cl], hydrous mineral modal

abundance, or other proxies for addition of fluid or melt (e.g., Ba/Nb, Ce/Sm). Although Cl

enrichment in NAM is likely related to Farallon-derived metasomatism, it is decoupled from

some indices of metasomatism and is not ubiquitously correlated to halogen enrichment in the

bulk xenolith. This is likely because hydrous minerals control the bulk halogen content of these

xenoliths.

**Keywords:** Geochemistry, Mantle, Volatile elements

A036 Ethan Conrad

**Deformation and exhumation at oblique margins: a study of the Northern Caribbean Plate Boundary in the Dominican Republic, Hispaniola**

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Obliquely convergent margins tend to experience temporally and spatially variable deformation patterns due to time-varying convergence rates, obliquity, and modes of strain partitioning. Yet, it is uncertain how these factors are linked to exhumation and the topographic development of oblique plate boundaries. To fully understand their current and evolving signatures, we must reconstruct and unravel margin evolution under variable tectonic scenarios. Here, we explore how a convergent margin progresses from thrust-dominated to wrench-dominated transpression using the northern Caribbean Plate Boundary (NCPB) as a natural laboratory. To investigate the evolving style and magnitude of deformation and exhumation, and the topographic response, we integrate structural geology and geomorphology with zircon and apatite (U-Th)/He low-temperature thermochronology. We focus on the Dominican portion of the Greater Antilles Island of Hispaniola, where the NCPB is well exposed. Structural analyses in the northern and central Cordilleras point to a multistage deformation pattern with marked spatial variation in style and geometry. Slickenline orientations point to a west-to-east increase in extension corresponding to along-strike changes in fault geometry and magnitude of exhumation. Structural overprinting in both Cordilleras indicates potential temporal changes in fault slip direction of >70º, likely accompanying local stress reorientations as the boundary transitioned to wrench-dominated transpression. Stream and topographic analyses suggest that the southwestern portion of the island accommodates most of the uplift and topographic response, while thermochronometric results constrain the timing, spatial magnitudes of exhumation, and the control of major faults on spatial trends in exhumation rates. Based on these integrated analyses, we propose that the NCPB experienced multistage adjustments in strain partitioning during the plate boundary's transition, reflected by changes in fault kinematics and geometry, spatiotemporal exhumation trends, and the development of topography. Deformation appears to have intensified in the Miocene related to the accretion of thick Caribbean crust, rejuvenating deformation and exhumation across the island.

A037 Eric Hiatt

**Limited Recharge of a Steady Deep Groundwater Aquifer in the Southern Highlands of Early Mars**

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The planet Mars is currently cold and arid, but this was not always the case. Convincing geomorphic and geochemical evidence suggests Mars had at least an ephemerally active hydrosphere in the Noachian period, ~ 4 Ga ago. Weakly integrated fluvial networks, called “valley networks”, dissect the oldest terrains. Light layered deposits, in an area known as Arabia Terra, are thought to be formed via evaporitic processes as a fluctuating groundwater table cyclically breached the topography and then receded. The valley networks are pervasive across Noachian aged terrains and the presence of the light layered deposits in Arabia suggest that the area was, uniquely, a depositional environment. This unique environment sits on the planetary dichotomy, a line that delineates the ~4 km transition in topography from the northern lowlands and southern highlands. This is the oldest observable feature on the planet and was caused by either mantle convection processes or a large oblique impact. Two very large impact basins, named Hellas and Argyre, are also prominent features on the planet. The southern lowlands, Hellas, and Argyre would have been planet scale sinks for any hydrologic system. Using the geomorphic observations as constraints and putative shoreline elevations, we ask; what are plausible groundwater recharge rates on early Mars? To answer this, we develop analytic and numerical solutions for an unconfined steady-state aquifer beneath the southern highlands. Using the Dupuit-Forchheimer approximation, we formulated our analytic and numeric solutions in a spherical shell geometry. The numeric model has periodic boundary conditions and a novel method for removing standing bodies of water from the computational domain. We show that the aquifer’s mean hydraulic conductivity, 𝐾, is the primary constraint on the plausible magnitude of mean steady recharge, 𝑟. By restricting groundwater upwelling to Arabia Terra, using a mean hydraulic conductivity of 𝐾 ∼10−7 m/s and varying shoreline elevations and recharge distributions, the mean recharge must be of the order of 10−2 mm/yr. Recharge for other values of 𝐾 can be estimated as 𝑟 ∼10−5 𝐾. Our value is near the low end of previous recharge estimates and two orders-of-magnitude below the smallest precipitation estimates. This suggests that, for a steady hydrologic cycle, most precipitation forms runoff, not groundwater recharge. It is also plausible that the transient aquifer response to recharge is sufficiently slow that no upwelling occurs prior to cessation of climatic excursions causing precipitation.

**Keywords:** Planetary, Hydrology, Modeling

A038 Hazal Kirimli

**Quantification of Environmental Impacts Associated with the Full Life Cycle of the Global Nickel Supply Chain**

*Hazal Kirimli  
Dr. Michael H Young*

The global energy transition to cleaner energy options has been accelerated by many ways since 2010s, by initiatives such as Paris Agreement, Glasgow Climate Pact, and Inflation Reduction Act. To achieve these ambitious goals, significant increases in manufacturing of energy infrastructure will be needed1. Nickel is a crucial industrial material for modern society, because of its specific qualities including toughness, ductility, stability at high-temperatures, and corrosion resistance2. It is an important input for high-performance technological products, such as stainless steel, batteries, and nickel-based alloys3. Clean energy technologies, such as solar photovoltaic, wind energy, and electric vehicles (EV) require more critical minerals (e.g. nickel, cobalt) than traditional fossil-fuel based technologies. For example, an average EV requires six times the mineral inputs compared to a fossil-fuel-powered vehicle, and an onshore wind energy plant requires nine times more than a natural gas-fired power plant1. Over the next two decades, as the climate goals are pursued, total demand for nickel is expected to increase 60-70%1. According to the U.S. Geological Survey, global nickel mine production has increased 50% in the last decade, from 1.8 Mt in 2011 to 2.7 Mt in 20214. However, nickel mining and production come at a cost to the environment and human health, due to high energy intensity, high greenhouse gas emission, and solid waste generation.

The aim of this research is to provide a comprehensive life-cycle assessment to fully understand environmental impacts of global nickel supply chains. Because factors affecting commodities (e.g. extraction technology, economics, and reserve characteristics) change frequently, the feasibility and economic viability of production changes dynamically as well. Efforts on environmental impact assessment of nickel, thus far, are mostly based on nickel from sulfuric ore only. However, existing sulfuric ore deposits have been depleted and there is a lack of new ones5. Although processing nickel laterites have higher carbon footprint, there is a growing trend in nickel production from lateritic ore6. Moreover, different nickel production technologies cause high variations in emissions. Therefore, assessments with up-to-date and site-specific data are vital. Results are presented for selected nickel products with a functional unit based on one tonne of nickel content. The inventory data are compiled from literature and Ecoinvent v37 and processed in OpenLCA software with different scenarios of nickel production, such as nickel production with current operations, with maximum recycling and all virgin nickel production.

**Keywords:** Life-cycle assessment, mining, nickel, environmental impacts, batteries,

stainless-steel

A039 Daniel Ruiz Arriaga

**Early to Middle Jurassic Jurassic rifting in southern Mexico and implications for Gulf of Mexico opening**

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The Gulf of Mexico (GOM) is a major basin in the tectonic evolution of North America, whose evolution has been recorded in the offshore and onshore stratigraphic record of southern US and east and south Mexico. Early Mesozoic basins at eastern Mexico have been linked to the disgregation of the supercontinent Pangea and the opening of the GOM. However, the lack of resolution of the architecture and timing of the early syn- rift basins in south Mexico restricts our understanding of early GOM evolution. The early Mesozoic continental siliciclastic rocks of the Todos Santos Group (TSG) allow to enlighten the evolution and timing of pre-Oxfordian syn-rift strata, linked to westernmost Pangea break-up and later opening of the GOM. New stratigraphic, petrographic and detrital zircon (DZ) U-Pb provenance geochronology allow to understand the TSG rocks and link them with early Mesozoic basins rock record.

The basement of the Todos Santos Basin is formed by Paleozoic rocks of the Chiapas Massif Metamorphic Complex (CMMC), Paso Hondo, Grupera, and Santa Rosa Formations. The early Jurassic volcanics and siltstone of La Silla Fm, overlay the basement rocks. On top of La Silla Fm, the syn-rift Jiquipilas formation is formed by 2 stratigraphic features: siltstone and fine sandstone of El Diamante facies, and coarse to medium sandstones of the Jericó facies. Lithology differences and local angular unconformities between these members link them to syn-tectonic deposition episodes after the La Silla volcanics and before the Oxfordian San Ricardo Fm siltstone and anhydrites.

Sinemurian to Pliensbachian U-Pb ages of La Silla volcanics confirm a pulse of magmatism. Maximal depositional ages (MDAs) of 190-180 Ma of the El Diamante siltstone and the 178-168 Ma and 164 Ma of the Jerico sandstones suggests deposition of the TSG rocks as early as the Pliensbachian. The Toarcian MDAs suggest a second episode of syn-tectonic deposition followed by a Callovian episode. Also, the El Diamante Proterozoic and Paleozoic age populations switch to Jerico’s dominant Permo-Triassic populations, indicating a change in the drainage system and sediment sources. The sources change from an initial input from the CMMC into a more dominant Chiapas Batholith and Jurassic Nazas Arc volcanic age populations.

The ages of La Silla Fm match with the volcanic record and MDA’s of syn-rift sequences in east Mexico suggesting that magmatism at the Todos Santos Basin is coeval to early Jurassic rifting and back arc extension. Additionally, El Diamante Toarcian MDA suggests that such rocks were linked to late back-arc extension at westernmost Pangea, previous to the opening of the GOM. These data enlighten the sedimentary response from western Pangea’s extensional tectonics.

A040 Mikayla Pascual

**Quantifying the impact of seasonal forcings on the timing of Greenland Ice Sheet outlet**

**glacier terminus retreat**

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Large parts of the Greenland and Antarctic Ice Sheets drain out to the oceans through marine-

terminating outlet glaciers, many of which have accelerated their flow and are contributing to

global sea-level rise. Ice sheet projections, created using numerical models of ice flow, are used

to understand future contributions to sea-level rise and previous studies have shown that seasonal glacier dynamics can impact the timing of glacier retreat. However, numerical ice sheet and glacier models usually omit seasonality, prescribing only annual climate forcings, and this may lead to uncertainty in future projections of sea-level rise. Here, we compare numerical ice-sheet model simulations forced with seasonal versus annual in atmospheric and oceanic forcings to test how excluding seasonality can bias projections of glacier change. We run simulations using the Ice-sheet and Sea-level System Model (ISSM) to investigate four outlet glaciers in central West Greenland from 1985 to 2015 and compare the model results against observations. We find that seasonality in the forcings leads to a ~10 gigaton difference in ice mass loss when compared to the simulations that are forced with annual climate forcings. We also find that including seasonality can bias ice thickness and glacier terminus positions over time for some glaciers but not others. Ultimately, by improving how seasonal forcings are implemented in ice sheet models, studies like ours will help to improve decadal and centennial projections of ice sheet change and sea-level rise.

**Keywords:** Glacier seasonality, Glaciology, West Greenland

A041 Charles Babendreier

**Massive Submarine Landslides Imaged Offshore Southern Oregon**

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Submarine landslides are gravity-driven, mass transports that occur beneath the sea surface along the slopes of underwater geologic features (e.g., continental slopes, submarine canyons). In some cases, submarine landslides can destroy valuable ocean bottom infrastructure and/or generate tsunamis, posing risk to nearby coastal communities. At the Cascadia Subduction Zone off the west coast of the U.S. and Canada, the oceanic Juan de Fuca Plate slides beneath the continental North American Plate. Previous bathymetric and seismic imaging have shown that submarine landslides are ubiquitous along the Cascadia margin. In 2021, new multi-channel seismic data were acquired onboard the R/V M. G. Langseth using a 12-km hydrophone streamer and a 6600 in3 airgun source through the CAscadia Seismic Imaging Experiment 2021 (CASIE21). Using this dataset, we have an unprecedented opportunity to map the buried deposits of submarine landslides and characterize their structure along this margin. We identified 10 massive submarine landslide deposits offshore southern Oregon (latitudes 42¬∞-44¬∞ N). Landslide deposits of this scale are not observed elsewhere along this margin. Two of the older deposits, both near 44¬∞ N, have the largest spatial extent. They are imaged over 55 km seaward of the deformation front and cover an estimated area of 17000 km2 and 7430 km2, respectively. The mean estimated surface area of the other eight events is 470 km2. Six of the ten observed slides exhibit compressive thrust features contained mostly within the seaward portion of the deposit. These are interpreted to be zones of impact-induced deformation from the slide material. Six of the ten deposits also contain at least one distinct region of high-amplitude, semi-coherent reflections, which we interpret to indicate detached slide blocks. Our observations from the seismic images suggest that most of these slides failed and displaced as cohesive bodies with high seafloor impact-velocities. Given the size and style of deformation of these deposits, some of these events could have generated great tsunamis. Detailed stratigraphic analyses reveal that all but two of these deposits post-date a previously determined stratigraphic boundary believed to mark the onset of the Nitinat submarine fan (at approximately 0.76 Ma) to the North. First-order constraints on the timing of these landslides allow us to consider the amount of the deposits which has been lost to subduction/frontal accretion. The effect of subduction-related reduction in observed deposit size is greater for the oldest deposits; in the case of the oldest and largest deposit, approximately 33% of the original deposit runout and 35% of the original deposit area have been subducted.

**Key Words:** Landslides, Geohazards, Subduction

A042 Graciela Lopez Campos

**Impact of fault orientation and friction angle on the stress state of an accretionary prism**

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We study large-scale deformation and stress in accretionary wedges with a splay fault that is

weaker than the wedge sediments using evolutionary geomechanical models. We model

sediments as porous-elastoplastic materials and vary the fault orientation and friction angle.

These preliminary models are drained and we model the fault as a pre-existing contact surface.

We find that the lower frictional strength of the fault results in a decrease in sediment differential stresses, and a more isotropic state of stress near the fault. We demonstrate how the differential stress – hence the maximum principal stress the sediments can support – decreases with decreasing fault strength. We also find that the sediments can support the largest maximum principal stress when a fracture has orientation close to the decollement angle or perpendicular to it; the maximum principal stress decreases when the fracture dips between 75 and 10 with a minimum at about 45. Our results offer a significant improvement over previous, continuous models of subduction zones that predicted Coulomb failure throughout the wedge. Our preliminary findings favor slipping along the faults; hence they might contribute to the geomechanical understanding of a variety of field observations, including evidence of a brittle deformation response (slipping) along splay faults as seen on seismic profiles, stratigraphic offsets in drill holes and dilative calcite veins obtained from the Lesser Antilles Arc and Nankai. They may also provide an alternative explanation to the reduction of principal stresses post- failure usually attributed to fluctuations of pore pressure.

A043 Omar Alamoudi

**Permeability and fracture evolution with confining pressure: an experimental study utilizing X-ray computed tomography and pulse-decay permeability measurements**

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Understanding fluid flow in fractured rocks is relevant to many applications, from hydrocarbon production enhancement, hydrothermal energy, cap rock integrity for nuclear waste management and CO2 sequestration. One approach used by geoscientists to better understand such flow in the subsurface is to subject cylindrical rock samples to loading conditions in the laboratory similar to those in the subsurface, and study how fluids flow through it. This is usually done using Tri-Axial Testing Apparatuses or Hassle-type cells. These apparatuses are usually sealed and obscure the sample from the user. Interpretations of loading and deformation measurements, i.e., stress and stain curves, are then used to analyze the deformation and evolution of the fractured rocks. This approach leaves in understanding the localized deformation and focuses on the cumulative effect of the deformation.

With the availability and access to Three-Dimensional X-Ray Micro-Scale Computed Tomography (microCT), and by building an X-Ray Transparent Tri-Axial Apparatus (X-RETTA) with an aluminum sample enclosure, we were able to ‚Äúvisually‚Äù probe microCT models of a fractured rock sample at different loading conditions. In addition, we built a permeability instrument that integrates with the X-RETTA with a small footprint such that permeability measurements can be acquired while the X-RETTA is mounted inside the microCT scanner. This allowed us to rapidly alternate between microCT image acquisition and measuring the permeability of the sample with minimal disturbance of the sample and its positioning with the microCT scanner. We present a 4D model (3D + time) of a fractured rock sample undergoing different loading conditions, Results show the evolution of the fracture with the associated permeability measurements and fracture healing. We used a mudstone already study by Blanf and collaborators to study the permeability of the Hikurangi margin in New Zealand.

In addition, using numerical quantitative analysis of the microCT models of the rocks, we estimate different fracture properties, in particular the fracture aperture at different loading conditions and correlate that with the permeability measurements. Our results show that the measured permeability decreases with increasing loading on the sample as a result of the fracture aperture reduction and healing.

**Key Words:** Permeability, Fractures, microCT

A044 Danqi Jiang

**Outer Wedge Deformation Evolution Along the Cascadia Subduction Margin and its Implications on Megathrust Slip Behaviors**

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The outer accretionary wedge experiences significant active shortening and imbricate thrust faulting and responds more quickly to changing boundary conditions than the thicker, older parts of the wedge. Therefore, it provides insight into active subduction processes and associated geohazards. The structure and physical properties of the outer wedge have been proposed to control the fluid content and frictional properties of the megathrust fault, thus influencing the seismogenic behavior along the subduction megathrust.

The Cascadia subduction margin is unusually quiet with very little instrumentally recorded interplate seismicity. However, paleo-seismic records indicate that this margin has hosted Mw ~9 earthquakes with recurrence intervals of 250-500 yr during the Holocene. Thus, it poses major earthquake and tsunami hazards to the heavily populated Pacific Northwest. Previous studies proposed that the region with landward-vergent faults in the outer wedge offshore Washington and northern Oregon correlates with the highest degree of plate interface coupling along the Cascadia margin and has the largest rupture patches during paleo-earthquakes.

Here, we conduct structural and stratigraphic interpretation on 19 dip lines from the newly acquired CASIE21 dataset to map the structure of outer wedge (in particular, fault vergence) along the margin and investigate its relation to megathrust slip behavior. Our preliminary results show that the faults in the outer wedge are dominantly seaward- to mixed-vergent offshore Vancouver Island, landward-vergent offshore Washington, mixed-vergent offshore northern and central Oregon, and seaward-vergent offshore southern Oregon. The landward-vergent faults with an average dipping angle of 46.3°are in general steeper than seaward-vergent faults with an average dipping angel of 32.1°, which provide more effective drainage pathways for fluid in the outer wedge and contribute to form a more rigid wedge that can rupture over long distance in megathrust earthquakes. In addition, sediment subduction is minimal beneath outer wedge dominated by landward-vergent faults, thus the plate interface has little fluid input from subducted sediments, limiting its potential for overpressure and contributing to strong coupling.

**Keywords:** Outer Wedge, Cascadia Subduction Margin, Megathrust Slip Behaviors, Landward-vergent Faults, Sediment Subduction

A045 Mae Stone

**Evaluating the Economic Value of the UT-0D0 Planet and the Habitability of the System.**

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An exoplanet is a planet orbiting a star outside of our solar system. Hypothetical exoplanet UT-0D0 is a giant planet with no surface water, and little atmosphere, but rich in mineral resources and possibly organic material. The planet’s adjacent moon consists of freshwater ice and a liquid ocean underneath. However, the habitability of the system is unknown. Here we show that access to valuable resources and the opportunity for human habitability may be present within the system. Because there is virtually no atmosphere in the system, it would be ideal to paraterraform UT-0D0’s moon to access available frozen fresh water. Additionally, reverse osmosis could be used to desalinate ocean water below the icy shell. Using Europa as an analog for this system’s moon, it may be possible to harness the power of tidal forces on the moon. There are also viable plumes, and possibly geothermal vents signaling life could exist on the UT-0D0 moon. Because of the gravity of UT-0D0, a rover could be used to ethically collect abundant valuable resources such as iron, magnesium, and quartz located on the surface. Additionally, the highlands are composed of purple-colored rock, signaling the presence of organic matter that could be of significant use if viable, and possible evidence of previous life. Additionally, the lowlands consist of orange-yellow rock that may be composed of oxidized minerals, possibly indicating water below the surface. Our results demonstrate that the system has a habitable moon and UT-0D0 could be of significant economic value to humanity because of the abundant resources found on the surface. The surface of UT-0D0 warrants further studies to determine the quality of the soil, organic matter, and the possibility of water below the surface.

A046 Elena Alvarado

The habitability of exoplanets is of much interest to scientists today. A variety of exoplanets have been found orbiting other stars. These planets in other solar systems may have the possibility of one day hosting human life. Therefore, this study aims to examine the potential habitability of a planet entirely covered with shallow to deep water. The theoretical planet UT-0F30 contains the potential for water, solar, and wind energy, and a moon that may have mineral resources. Additionally, planet UT-0F30 has mild seasons, earth-like temperatures, and liquid water. However, the water available on this planet is salty and therefore not directly drinkable, and the air is not breathable. We may be able to assess this planet by comparing portions of UT-0F30 to the analog of an epeiric sea. An epeiric sea is a shallow sea that covers a continental shelf. We chose to use past and present epeiric seas such as the Western Interior Seaway as analogs as they are shallow, saline, and sometimes also had anoxic ocean floors, similar to UT-0F30’s lack of oxygen, but warm climate. Challenges associated with habitability include saline water and an atmosphere composed of mainly carbon dioxide with little to no oxygen; however, these issues can be mitigated with technology such as reverse osmosis, non-potable reuse of water and biological oxygen production. Though there is promise for habitability, further information about the resources available on the moon, plate tectonics on the planet, and nutrient availability would be necessary in future research.

A047 Shuhua Hu

**Uncertainty quantification of full waveform inversion using adaptive Metropolis adjusted Langevin algorithm**

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Uncertainty quantification (UQ) is crucial for seismic full waveform inversion (FWI), which is a highly ill-posed inverse problem. In the framework of Bayesian inference, seismic FWI can be regarded as the usage of appropriate sampling methods to explore the model space given seismic data. By doing this, we acquire an overview of the statistical features of the model space, producing posterior distributions enabling uncertainty analysis.

In this abstract, an adaptive version of the Metropolis adjusted Langevin Markov chain Monte Carlo (MCMC) sampling algorithm is proposed to quantify the uncertainties in FWI. In the adaptive sampling process of Metropolis adjusted Langevin algorithm (MALA), the proposal covariance matrix is approximated using previous samples, and the proposal step length is adaptively updated based on criteria of optimum accept rate. By introducing the adaptive covariance and step length in the proposal probability distribution, the algorithm is able to draw samples more efficiently compared to a proposal distribution with unity covariance and fixed step length.

The algorithm is numerically implemented with a frequency domain FWI example for acoustic Marmousi model. Results show the effectiveness of the proposed method.

**Key Words:** Full waveform inversion, Uncertainty quantification, MCMC

A048 Madison Preece

**Interpreting possible active tectonic structures from DEM analyses of the Nepalese Himalayas**

*Madison Preece*

*Joel Johnson*

*Ryan Thigpen*

Active tectonics result in landscape scale deformation, which is expressed as distinguishable topographic features. Geomorphic indices such as watershed steepness and knickpoints in channel profiles are useful for interpreting tectonic activity from topography. Here we use a digital elevation model (DEM) from NASA Shuttle Radar Topography Mission (SRTM) to interpret possible active tectonic structures in regions of the Nepalese Himalayas. Our analyses show an orogen-parallel zone of increased steepness values near the location of the main central thrust (MCT). This zone is coincident with an area of focused erosion caused by seasonal monsoons, which has been suggested to cause isostatic rebound and activation of tectonic structures. Stream profiles show knickpoints that correspond with the zone of increased steepness. Future work will include comparisons with across-strike variations in lithologies to help determine if these features result from tectonic activity, differences in rock strength, or possible climatic controls from precipitation patterns.

A049 Caitlin Moeller

**Multi-stage degassing of CO2 and H2O from intraplate magmas and its geophysical and geochemical implications**

*Caitlin Moeller and Chenguang Sun*

Magmatism is an efficient process that extracts volatile elements from Earth’s interior to its surface. During buoyancy driven migration, the mantle-derived melts begin to degas dissolved volatiles upon reaching fluid saturation, the depth of which can be estimated using the solubility of CO2 and H2O in silicate melts. However, the inferred degassing pressures for magmas from mid-ocean ridges, arcs, and ocean islands are generally in the shallow or middle crust. As these magmas have distinct volatile compositions in their primary melts, the similar degassing depths indicate complex magmatic degassing histories, especially those from thick lithosphere (e.g., arc and ocean island lavas). Using multiple solubility models and olivine- hosted melt inclusion data from the literature, we focus on the Hawaiian Islands to investigate the degassing processes of intraplate magmas during melt transport from the mantle to surface and during melt crystallization in crustal magmatic zones. A major reason of selecting the Hawaiian Islands as a representative example is the availability of independent estimations for CO2 and H2O contents of the Hawaiian mantle source in the literature. We show that the initial depths of volatile degassing from the primary melts are below Moho and comparable with those of deep long-period earthquakes beneath the Hawaiian volcanoes [1]. Such a deep volatile degassing process is likely important to facilitate rapid melt migration through the lithosphere. As the deeply degassed fluid is dominated by CO2, it reduces the partial pressure of H2O and can then enable H2O degassing prior to the saturation of pure H2O. In addition, our results show that the magmatic fluid can become enriched in H2O either at shallower depth or during late-stage crystallization. This indicates that variations of H2O/CO2 ratios in volcanic emissions may not result solely from changes of degassing depths. [1] Wech et al. (2020) Science.