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The Use of Detrital Zircon Maximum Depositional Ages Through the Lens of an Arc- Unroofing Sequence, Great Valley Group, California*Jacqueline Epperson**Epperson, Jacqueline J.**Malkowski, Matthew A.*

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: U-Pb detrital zircon geochronology, maximum depositional age

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Soil, Water, and Agriculture in the Mediterranean: A Need for Sustainability Policy*Tara Greig**Greig, T., The University of Texas at Austin, Austin, TX*

The population of the Mediterranean region is expected to grow roughly 12% in the next 15 years while continually facing climate pressures. Current soil, water, and agriculture management may not be able to support growing demand for food, water, and environmental protection. Regenerative farming has shown promise through increasing soil organic carbon stocks, increasing soil biota, and decreasing soil erosion at multiple sites across the region and throughout the three most prevalent soil types in the region (cambisols, calcisols, and leptosols). Such soil outcomes also influence water use and quality as agricultural water use accounts for a large percentage of total water usage across the region. Irrigation is the predominate agricultural water system; however, many inefficiencies in irrigation technology currently exist. Outdated irrigation infrastructure coupled with exploitation of water resources further exacerbates water scarcity and quality. Policy has been proposed and adopted both by and between countries part of the region to support soil health and water availability. Such policies include promotion of several regenerative farming methods, but there is still insufficient support for this style of farming and the agriculturalists that could benefit from it. Water policy in the region is much more developed than soil policy but may still lack needed progressivity. Recently, wastewater recycling research and projects have been funded through water governance/policy initiatives. The viability and implementation of such a practice could dramatically reduce water scarcity throughout the region. The adoption of regenerative farming techniques (as encouraged or mandated by policy) alongside evolving water conservation programs could increase sustainability of the region.

Keywords: Mediterranean, Agriculture, Sustainability, Regenerative Farming, Conventional Farming, Soil Health, Water Scarcity, Soil Policy, Water Governance

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Deriving Urban Canopy Parameters using a Deep Learning Method to Simulate Urban Heat Islanding Effect over Houston, Texas*Harsh Kamath**Kamath, H., Jackson School of Geosciences, The University of Texas at Austin, Austin, TX**Singh, M., Jackson School of Geosciences, The University of Texas at Austin, Austin, TX**Yang, L., Jackson School of Geosciences, The University of Texas at Austin, Austin, TX**Niyogi, D., Jackson School of Geosciences, The University of Texas at Austin, Austin, TX*

The urban heat islanding (UHI) effect impacts thermal comfort and urban energy consumption. To represent the urbanization in the mesoscale models such as the weather research and forecasting (WRF) model, world urban database and access portal tool (WUDAPT) was introduced. WUDAPT attempts to represent urbanization using the local climate zones (LCZs), where the urban canopy parameters (UCPs) of a city such as the building and vegetation canopy heights and distributions are described. However, deriving the UCPs for the WRF model parameterization is a challenge. Here, to derive the UCPs, we downscale the 30 meters ALOS digital surface model (DSM) to 1 meter using the super resolution convolutional neural network (SRCNN) with open street maps building footprints and population density as auxiliary variables. The model is trained using LIDAR derived DSM at 1 meter resolution over 11 cities (not including Dallas) in the US and the prediction is over Dallas, Texas. The preliminary results show that the mean building heights derived from SRCNN has a good agreement with the LIDAR DSM and shows a substantial value addition over the coarse resolution ALOS DSM.

We compare the UHI simulated with WRF using the UCPs predicted by SRCNN and an existing robust urban dataset over the US known as the national urban database and access portal tool (NUDAPT). These simulated UHIs will be further compared with the observed temperature.

Keywords: LIDAR, Deep learning, Urban heat islanding, WRF

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A Novel Approach to Systematically Analyze the Error Structure of Precipitation Datasets using Decision Trees*Xinxin Sui**Sui, X., Department of Civil, Architectural and Environmental Engineering, The University of Texas at Austin, Austin, TX**Li, Z., School of Civil Engineering and Environmental Science, University of Oklahoma, Norman, OK**Tang, G., Centre for Hydrology, University of Saskatchewan, Canmore, Alberta, Canada**Yang, Z., Jackson School of Geosciences, The University of Texas at Austin, Austin, TX**Niyogi, D., Jackson School of Geosciences; Department of Civil, Architectural and Environmental Engineering, The University of Texas at Austin, Austin, TX*

Multiple environmental factors influence the error structure of precipitation datasets. The conventional precipitation evaluation method over-simplifies how the statistical indicators vary with one or two factors via dimensionality reduction. As a result, the compound influences of multiple factors are superposed rather than disassembled. To overcome this deficiency, this study presents a novel approach to systematically and objectively analyze the error structure within precipitation products using decision trees. This data-driven method can analyze multiple factors simultaneously and extract the compound effects of various influencers. By interpreting the decision tree structures, the error characteristics of precipitation products are investigated.

Three types of precipitation products (two satellite-based: ‘top-down’ IMERG and ‘bottom-up’ SM2RAIN-ASCAT, and one reanalysis: ERA5-Land) are evaluated across CONUS. The study period is from 2010 to 2019, and the ground-based Stage IV precipitation dataset is used as the ground truth. By data mining 60 binary decision trees, the spatiotemporal pattern of errors and the land surface influences are analyzed. Results indicate that IMERG and ERA5-Land perform better than SM2RAIN-ASCAT with higher accuracy and more stable interannual patterns for the ten years of data analyzed. The conventional bias evaluation finds that ERA5-Land and SM2RAIN-ASCAT underestimate in summer and winter, respectively. The decision tree method cross-assesses three spatiotemporal factors and finds that underestimation of ERA5-Land occurs in the eastern part of the rocky mountains, and SM2RAIN-ASCAT underestimates precipitation over high latitudes, especially in winter. Additionally, the decision tree method ascribes system errors to nine physical variables, of which the distance to the coast, soil type, and DEM are the three dominant features. On the other hand, the land cover classification and the topography position index are two relatively weak factors.

Keywords: Decision tree, precipitation product evaluation, land surface influences, data mining

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Community Abundance Analysis to Support Coral Reef Management in East Portland Special Fishery Conservation Area, Jamaica*Claire Williams**Williams, C., Jackson School of Geosciences, The University of Texas at Austin, Austin, TX**Martindale, R., Jackson School of Geosciences, The University of Texas at Austin, Austin, TX**Henry, D., Alligator Head Foundation, East Portland, Jamaica**AHF Monitoring Team, X., Alligator Head Foundation, East Portland, Jamaica*

Global warming and human impacts are and will continue to be devastating for coral reef systems. Jamaican reefs, in particular, 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 area that is being protected is The East Portland Special Fishery Conservation Area (EPSFCA). The EPSFCA is a “no take zone” 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 or ecosystem mapping 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, water quality assessments, and invertebrate counts conducted by AHF staff). Ordinations highlight the similarity between monitored sites and track changes in reef composition to aid further conservation plans.

An analysis of EPSFCA reef sites monitored from 2017-2019 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). Much of the variation between these sites can be explained by the abundance of turf algae and the corals *Colopophyllia natans*, *Mussa anguosa*, *Dichocoenia stokesi*, and *Acropora cervicornis*. Fish populations were more similar, but the main fish species that drove differences between sites were the parrotfish *Sparisoma chrysopterum*, *Scarus vetula*, and *Scarus guacamala*. The ultimate goal of this project is to combine this data from EPSFCA with environmental information in an ecological niche model to provide a road map for where conservation efforts are most likely to succeed and/or where more work needs to be done to protect the ecosystem.

Keywords: Reef, Community Abundance, Conservation

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Quantification of Environmental Impacts Associated with the Full Life Cycle of the Global Nickel Supply Chain*Hazal Kirimli**Kirimli, H., Bureau of Economic Geology at University of Texas, Austin, TX, USA*

The global energy demand is forecast to grow approximately 50% by 2050, while experiencing a rapid energy transition to low-carbon technologies. Nickel is one of the most important keys with its toughening, strengthening against high-temperatures, and anti-corrosion properties. It is widely used in stainless-steel, batteries, and nickel-based alloys. The global boom of EVs and significant expansion of the stainless-steel industry in China makes nickel an essential material globally. However, nickel mining and production come at a cost to the environmental and human health, due to high energy intensity, high greenhouse gas emission, and solid waste generation. The focus of this research is on quantifying environmental impacts associated with the full life cycle of the global nickel and nickel products. Currently, China accounts for around 35% of the global nickel production. There is a lack of up-to-date primary emissions data available for Chinese-owned nickel production facilities, hampering estimates of correct emissions and evaluations of environmental impacts. Moreover, efforts on environmental impact assessment of nickel, thus far, are mostly based on nickel from sulfidic ore only. However, existing sulfidic ore deposits have been depleted and there is a lack of new ones. Although processing nickel laterites have higher carbon footprint, there is a growing trend in nickel production from lateritic ore. This research aims to demonstrate the change in the amount and degree of environmental impacts associated with global nickel production. Results will be presented for selected nickel and nickel alloy products with a functional unit based on one ton of nickel or nickel alloys. The inventory data is compiled from literature and Ecoinvent v3 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, Nickel, Critical Mineral, Environmental Impact, Nickel Production, Nickel laterite

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Micropaleontology and Isotope Stratigraphy of the Upper Aptian to Lower Cenomanian (~114-98 Ma) in ODP Site 763, Exmouth Plateau, NW Australia*Ali Alibrahim**Alibrahim, A., The University of Texas at Austin, Austin, TX**Leckie, R., The University of Massachusetts at Amherst, Amherst, MA*

Major oceanic events, including Oceanic Anoxic Event 1b, have been studied in northern hemisphere but were rarely studied in the southern high latitudes. Understanding these events offers important stratigraphic information for resource exploration and offers crucial insights in the paleoceanographic conditions that may have led to oceanic anoxia. Ocean Drilling Program Site 763, drilled on Exmouth Plateau, provided an excellent opportunity to investigate the presence of Oceanic Anoxic Events in the southern high latitude. The biostratigraphy and isotope stratigraphy of the upper Aptian to lower Cenomanian interval are studied in this site including Oceanic Anoxic Events OAE1b, 1c and 1d. OAEs of the Atlantic and Tethyan basins are typically associated with organic carbon-rich black shales and $\delta^{13}\text{C}$ excursions. Unlike other records, OAEs at this high latitude site did not coincide with black shales deposition and were instead marked by sharp declines in benthic and planktic foraminifera and/or enhanced pyrite formation. The Aptian/Albian boundary is placed at a negative carbon isotope excursion associated with the first appearance datum of *Microhedbergella renilaevis*, typically found within the Niveau Kilian black shale of OAE1b. Sea surface temperatures may have cooled by as much as 11°C in the late Aptian and increased gradually in the Albian as interpreted from Oxygen isotope data of bulk carbonates and planktic and benthic foraminifera. Third-order sea level cycles (1.5 to 3 million years) were interpreted in the middle Albian, based on cyclic changes in the abundance of inoceramid bivalve prisms in addition to carbon and oxygen isotope records of two benthic foraminifera; *Osangularia schloenbachi* and *Gavelinella* sp. The late Albian OAE1c and OAE1d coincide with horizons of intense pyritization and the absence of all biocomponents suggesting the development of euxinia. Warm Tethyan waters may have reached the Exmouth Plateau in the late Albian due to the incursion of keeled planktic foraminiferal taxa, including *Planomalina buxtorfi* and species of *Rotalipora* and *Praeglobotruncana*, which are typical of warmer low latitudes.

Keywords: Oceanic Anoxic Event, Isotope Excursions, Planktonic Foraminifera, Aptian Cooling, Inoceramid bivalve prisms

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Magnitude, Timing, and Rate of Sea Level Change During the Marine Isotope Stage 5e High Stand as Recorded by Pleistocene Coral Reef Limestone Deposits of the British West Indies

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Accurate prediction of the timing, rate, and magnitude of future sea level (SL) change is critical for global society to make sustainable, realistic, and economically viable plans to respond to climate change. However, complex intertwined dynamics of glacial isostatic adjustment and ice sheet distribution have made it challenging to predict with certainty future rises and falls in global mean sea level (GMSL). SL history in the most recent high stand during Marine Isotope Stage 5e (MIS 5e) at ~110-130 ka remains highly controversial. Recent published reconstructions vary from the MIS 5e being one major SL rise (+2-3 m;), to multiple events of SL rise and fall (+2m to 0 m to +5-6 m), to no SL change at all. There is significant importance to study the magnitude and timing of an intra-MIS 5e fall as this would indicate a short-term fluctuation of significant magnitude and represent a major fluctuation in SL over a very short (< 3ka) time interval not predicted by models of solar insolation. This begs the question: What was the magnitude, timing, and rate of sea level change during the MIS 5e high stand? Documenting and discerning such rapid and non-periodic shifts in GMSL are essential for a more robust understanding of impacts of global warming on coastal change.

The goal of this study is to test the hypothesis that: A short-term 3m magnitude sea level fall during the Pleistocene intra-MIS 5e high stand formed a regional, and potentially globally distributed subaerial exposure unconformity. The environmentally sensitive high-fidelity record of SL change including carbonate rock exposures of Pleistocene intra-MIS 5e marine limestones deposited on West Caicos, Turks and Caicos Islands (TCI) will be studied to answer this hypothesis. Specifically, an intra-MIS 5e unconformity which is: (1) underlain by coral boundstones and other marine grainstones; (2) a surface beveled through the underlying lithologies, leaving truncated *in situ* 1+ m-diameter coral heads with polished red crusts; (3) overlain by an ~1 m-thick erosional conglomerate and shallow marine shore-face to foreshore ooid grainstones, which vertically grade into aeolian grainstones. Field mapping and detailed sampling will be synthesized and precisely triangulated within a 3D cm-scale digital model to determine the elevation of SL from facies successions and unconformity-related diagenesis along the outcrop belt of West Caicos. Six transects along the west coast of West Caicos will be taken to provide the stratigraphic framework for hand sample collection. A sequence of 50 hand samples will be cut into billets, impregnated with Petropoxy, and made into 25 mm-thick, doubly polished, uncovered, standard petrographic thin sections and imaged with plane light and autofluorescence microscopy. Results will be synthesized to determine depositional facies (grain/fossil identification) and diagenetic alteration (calcite cement, evidence of subaerial and/or marine exposure) to create a paragenetic sequences below, across and above the intra-MIS 5e unconformity.

Keywords: MIS 5e, sea level change, sea level magnitude, intra-MIS 5e unconformity, diagenesis

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How Old is the Ordovician-Silurian Boundary GSSP at Dob's Linn, Scotland?

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Dob's Linn (Scotland) is a location that has significantly influenced our understanding of how life evolved over the Ordovician to early Silurian including comprehending, and time constraining the Late Ordovician Mass Extinction (LOME). The current chronostratigraphic boundary between the Ordovician and Silurian periods is a Global Boundary Stratotype Section and Point (GSSP) at Dob's Linn calibrated to 443.8 ± 1.5 Ma, partly based on biostratigraphic markers, radiometric ages, and statistical modeling. Graptolites are used here as relative dating markers. We dated hundreds of zircon grains extracted from defined metabentonites from four ash horizons exposed at Dob's Linn using Laser Ablation Inductively Coupled Plasma Mass Spectrometry (LA-ICP-MS), and several zircon grains using Chemical Abrasion Isotope Dilution Thermal Ionization Mass Spectrometry (CA-ID-TIMS). Each zircon was imaged using cathodoluminescence, and most show igneous zoning with minimal alteration or dimmed CL consistent with ash zircon grains. Sample locations range from 42 meters above to 5 meters below the recognized GSSP for the Ordovician-Silurian. Samples were responsibly collected and analyzed for paleontology and geochemistry in other work.

Overall, many ^{238}U - ^{206}Pb zircon dates obtained using LA-ICP-MS from the section are significantly younger than expected. The youngest zircon in sample DL7, located 5 meters below the GSSP, yielded a ^{238}U - ^{206}Pb date of 402 ± 12 Ma (5% disc) with a Young Statistical Population (YSP): 411 ± 3 Ma, Weighted Mean (WM): 434 ± 1 Ma, and a TuffZirc age of $435 +4 -2$ Ma. The youngest zircon in sample 19DL12, < 1 m below the GSSP, is 377 ± 8 Ma (2% disc) with a (YSP): 424 ± 2 Ma, (WM): 432 ± 1 Ma, and a TuffZirc age of $442 +8 -10$ Ma. A sample located directly on the GSSP (19DL09) yields the youngest zircon date of 327 ± 5 Ma (0.8% disc) with a (YSP): 329 ± 2 Ma, (WM): 425 ± 1 Ma, and a TuffZirc age of $447 +7 -8$ Ma. We also dated two samples (DL24 and BRS23) 8 meters above the GSSP, and the youngest most concordant zircon dates in these samples are 400 ± 11 Ma (5% disc) and 421 ± 9 Ma (0.4% disc) respectively. Sample DL24 includes a (YSP): 425 ± 0.4 Ma, (WM): 417 ± 0.3 Ma, and a TuffZirc age of $420 +3 -3$ Ma, while sample BRS23 encompasses a (YSP): 441 ± 1 Ma, (WM): 439 ± 1 Ma, and a TuffZirc age of $441 +2 -3$ Ma.

The CA-ID-TIMS preliminary dates would reassign the Dob's Linn's Ordovician-Silurian chronostratigraphic section with a Maximum Depositional Age (MDA) of **449 ± 0.8 Ma**. These CA-ID-TIMS results modify the *Parakidograptus acuminatus* biozone defining the Ordovician-Silurian boundary from Hirnatian-Rhuddanian to Katian (regionally Ashgill) age. The young U-Pb dates results from LA-ICP-MS could be attributed to Pb loss due to hydrothermal alteration during the Acadian and Alleghenian orogenies. Future work will implement more U-Pb zircon CA-ID-TIMS analyses to improve accurate age constraints on the Ordovician-Silurian boundary and evaluate the potential effects of Pb loss.

Keywords: Geochronology, Biostratigraphy, Geologic Time Scale, Extinction, Geochemistry, Geobiology, Fossil, Paleontology

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New insight on the pelvic anatomy of the aetosaur *Calyptosuchus wellsi* (Archosauria: Pseudosuchia) based on a new specimen from the Chinle Formation within Petrified Forest National Park, Arizona.*William Reyes**Reyes, W., Jackson School of Geosciences, University of Texas at Austin, Austin, TX 78712**Kligman, B., Department of Geosciences, Virginia Tech, Blacksburg, VA 86028**Marsh, A., Division of Resource Management, Petrified Forest National Park, Petrified Forest, AZ 86028**Parker, W., Division of Resource Management, Petrified Forest National Park, Petrified Forest, AZ 86028*

Calyptosuchus wellsi is one of the most common aetosaurians found within upper Triassic strata of the western United States, in particular from the Blue Mesa Member of the Chinle Formation and the Tecovas Formation of the Dockum Group. Anatomical understanding of *Calyptosuchus wellsi* is based primarily on the holotype and referred material from the *Placerias* Quarry in northern Arizona. Here, we present a new specimen (PEFO 46222), which we assign to *Calyptosuchus* based on a combination of osteoderm characters, with a nearly complete pelvic girdle collected from the Blue Mesa Member of the Chinle Formation within Petrified Forest National Park. This new specimen shows significant morphological variation from pelvic material (i.e., associated ilium and ischium; UCMP 25941 and 32148, respectively) referred to *Calyptosuchus wellsi* from the *Placerias* Quarry. Thus, prompting a reassessment of the pelvic anatomy of this taxon.

Based on a preliminary comparison of PEFO 46222 to the poorly preserved holotype (UMMP 13950) and referred ilium and ischium (UCMP 25941 and 32148, respectively) from the *Placerias* Quarry, we hypothesize that: 1) the referred elements do not belong to *Calyptosuchus wellsi* but to either *Desmatosuchus* or a paratyphosacine, which are also present in the *Placerias* Quarry; or 2) considering that the PEFO and UCMP material are roughly the same size, we are unlikely to be observing two individuals at different ontogenetic stages, instead they may represent two different species of *Calyptosuchus*. A more thorough comparative analysis is required to validate either hypothesis.

Keywords: Triassic, Paleontology, Archosaur, Anatomy, Aetosaur, Chinle Formation, National Park

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Competing Ice sheet and Insolation Forcing of the westerly storm tracks

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During the Last Glacial Maximum, the southwestern United States experienced wetter conditions, with evidence for expanded lake systems throughout the Great Basin, Arizona, and New Mexico. Early studies suggested that the cause of these hydroclimatic changes was a southward shifted winter storm track caused by the presence of the Laurentide Ice Sheet. Still, more recent studies have argued that wetter conditions were instead the result of redirecting of winter storms or strengthening of atmospheric rivers by an intensified the Aleutian low and/or North Pacific subtropical high. The latter mechanism has also been proposed to explain the lake level maximums seen during the deglaciation. Here, we use a new stable isotope and proxy temperature record from Cumbres Bog, in the San Juan Mountains of southern Colorado, to reconstruct changes in climate and moisture source dynamics from the LGM to present in order to understand the causes of these precipitation changes better. The stable isotope record, which we interpret as reflecting the proportion of winter precipitation reaching Cumbres Bog, indicates that winter moisture delivery was low at the LGM, increased suddenly at ca. 15 kyr, and then declined rapidly at ca. 12 kyr. The timing and out-of-phase behavior with precipitation records to the west are consistent with a meridional shift in the position of the winter storm tracks in response to the collapse of the Laurentide ice sheet. Furthermore, the lack of a deglacial millennial-scale signal in the Cumbres Bog record suggests that it was not associated with a shift in the storm track and may have been restricted to the westernmost part of the Great Basin. During the Holocene, changes in the proportion of winter precipitation reaching the southern Rockies increase following the strengthening of northern hemisphere summer insolation. This result is inconsistent with recent studies arguing for the weakening of the midlatitude westerlies in the mid-Holocene due to a reduced latitudinal temperature gradient.

Keywords: North American Monsoon, LGM, Westerlies, Southern US, Cumbres Bog

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Comparative Life Cycle Assessment of Traditional and Domestic Lithium Supply Chains*Zakariah Harner**Harner, Z., Bureau of Economic Geology, University of Texas, Austin, TX, USA*

With significant investment from public and private sectors alike into the development of battery materials production facilities across the United States, and with a plethora of domestic lithium extraction projects scheduled to come online over the next decade, a fully domestic lithium-ion battery supply chain is on the horizon. With such a radical shift in the lithium supply chain, from near-complete Chinese monopoly to rapid onshore development, environmental impacts associated with current lithium supply chains must be re-evaluated and assessed on a domestic level. This research will help inform policy makers and investors alike on the sustainability advantages and disadvantages of onshoring lithium and lithium-ion battery related production operations. This paper utilizes life cycle assessment, an internationally standardized methodology for assessing environmental impacts from cradle to grave operations involving a single product to quantify environmental impacts such as Global Warming Potential (GWP) in CO₂e, water use, and land use. Primary operational data were collected and qualitative analyses conducted via industry interviews. Life cycle inventory data were compiled and modeled in the software *OpenLCA* and combined with background data from the *EcoInvent* database. A comparison between traditional and domestic supply routes reveals significant room for reduction in greenhouse gas emissions generation via international freight shipping. A shift from traditional to domestic supply routes eliminates the need for midstream product shipment to and throughout China, reducing greenhouse gas emissions generated from international transport and via usage of less sustainable electricity generation mixes, as well as giving the United States a geostrategic advantage in global lithium-ion battery production capacity.

Keywords: Life Cycle Assessment, Lithium, Sustainable Supply Chains, Lithium-ion Batteries

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SIMULATING FREQUENCY DOMAIN SEISMIC WAVEFIELD USING PHYSICS-INFORMED NEURAL NETWORK

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Recently, machine learning (ML) algorithms has been widely applied in geophysical research. However, most of current ML applications are bounded in the framework of deep neural networks (DNNs) that behave like a black box with connected neurons. They typically require labeled data and need supervised training.

Recently, Physics-Informed Neural Network (PINN) has been proposed to solve seismic forward and inverse problems. Compared to conventional neural networks, PINN adds the physical governing equations as a regularization term to the loss function, which gives a physical meaning to the learning process. The added governing equations enhances the learning rate of the network and leads to a network with constraints given by physics.

In this work, we study PINN to solve frequency domain seismic wave equations. Both acoustic and elastic wave equations are framed into the PINN framework, in which the loss function is designed to incorporate the physics, boundary conditions and initial conditions. The performance of different activation functions in the NN are also compared. After training, PINN can output accurate seismic wave simulations that are comparable with traditional numerical methods, for instance finite difference, etc.

In this research, we utilize simple homogenous models and the synthetic benchmark Marmousi model to verify the correctness of PINN. It shows that PINN have the ability to solve the Helmholtz equation and produce correct solution. This shows the potentials of PINN in solving more practical problems such as full waveform inversion.

Keywords: Frequency domain, Seismic simulating, Physics-Informed Neural Network

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Multiphase flow studies for geological carbon dioxide (CO₂) sequestration using real rock microfluidics devices

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Over the past decade, the reduction of greenhouse gas emissions has become paramount to fight climate change and its implications on human life. While several efforts are being made worldwide to decrease emission levels, the geological storage of carbon dioxide (CO₂) represents a viable strategy applicable to capturing the CO₂ from large-scale sources. The injection of CO₂ into the subsurface is a complex process and the understanding of pore-scale phenomena is critical for the long-term and short-term assessment of stored CO₂. Microfluidic models are a convenient experimental framework that allows for optical visualization of flow patterns and precise control of the system at pore scale. However, current devices are limited to non-geological materials and emergent physical effects may not be captured under these conditions. This work focuses on the understanding of fluid migration and storage at the pore-scale using real rock highpressure microfluidic devices. Our study uses sandstones from the Gulf of Mexico to estimate saturations of trapped CO₂ in a brine saturated porous medium at reservoir scale conditions. The proposed methodology combines latest fabrication techniques with fluorescent imaging and computational technologies to provide a realistic assessment of the CO₂ storage in the subsurface.

Keywords: CO₂ storage, multiphase flow, microfluidics

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Deep Convolutional Autoencoder for Seismic Facies Characterization

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One of the final tasks to complete when processing seismic data is to determine the stratigraphy present in the dataset and classify it appropriately. Primary wave Impedance (P Impedance) and Vp/Vs models created following a partial stack inversion routine provide us with a convenient way to visualize the data as well as aiding in the non-trivial assignment of facies classification. A Bayesian approach to facies classification was utilized in which facies were determined for the Marco Polo dataset from the Gulf of Mexico with inputs from the P Impedance and Vp/Vs inverted models. The resulting facies map was used in tandem with the P Impedance and Vp/Vs models to then develop a deep convolution autoencoder featuring dropout layers (DCAED). Often, smaller features in input data are not well preserved in autoencoders so DCAED is tasked specifically at preserving said features. DCAED can take P Impedance and Vp/Vs models and output a facies map to help aid in the task of classification as the network correlates trends in changing impedance to changes in the facies present.

Keywords: Machine Learning, Seismic, Oil and Gas, Inversion

MG
ECG

Deep Ocean Circulation in the Southern Gulf of Mexico at the Eocene-Oligocene Transition

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The Eocene-Oligocene Transition (EOT) encompasses a series of potentially interconnected climatic, biotic, and paleoceanographic events within a longer-term Cenozoic greenhouse to icehouse climate transition. Changes in ocean circulation within the Gulf of Mexico (GOM) and the evolution of western North Atlantic deep-water flow are posited to be associated with these global events, which include 1) the development of a late Eocene stable, proto North Atlantic Deep Water (NADW) and subsequent initiation of Atlantic overturning circulation at the EOT; 2) the first major Antarctic glaciation, likely due to a significant drawdown of atmospheric CO₂; 3) a widespread extinction of benthic and planktic biota; and 4) a more complex ocean interior with increased stratification of Oligocene foraminifera relative to the Eocene. Modern GOM deep-water is connected to Atlantic Meridional Overturning Circulation via the Caribbean as NADW spills over the Yucatan Sill, filling the GOM with oxygen-rich deep-water. Although modern GOM circulation is well-studied, it is unclear how it may have recorded and possibly contributed to late Eocene development of Atlantic overturning circulation. Deep Sea Drilling Project Sites 95 and 540 are located at the mouth of the Yucatan Channel and Florida Straits north of potential sediment drifts identified in seismic data. These sites are ideal locales for characterizing deep-water exchange between the GOM, Caribbean, and western Atlantic. Here, we present preliminary X-ray fluorescence (XRF) and grain size analyses from Sites 95 and 540 and preliminary oxygen and carbon stable isotope data from Site 95. XRF and sortable silt data at Site 540 indicate probable increases in deep-water current intensity in the GOM through the Eocene-Oligocene Transition. However, significant coring gaps at Site 95 limit our ability to identify any long-term trends across multiple cores analyzed.

Keywords: Gulf of Mexico, Eocene-Oligocene Transition, benthic foraminifera, XRF, stable isotopes, grain size

MG

ECG

Methanogenesis, sediment burial and compaction, environmental limitations, microbial life*Addison Savage**Savage, A., Department of Geological Sciences, University of Texas, Austin, TX, USA**Smith, L.D., Department of Microbiology, University of Tennessee, Knoxville, TN, USA**You, K., Department of Geological Sciences, University of Texas, Austin, TX, USA**Flemings, P., Department of Geological Sciences, University of Texas, Austin, TX, USA**Mikucki, J., Department of Microbiology, University of Tennessee, Knoxville, TN, USA**Cowell, F., College of Earth, Ocean, and Atmospheric Sciences, Oregon State University, Corvallis, OR, USA*

Methane producing bacteria living within seafloor sediments are subjected to sediment burial and compaction, where shrinking pore spaces restrict cellular mobility, nutrients, and viability [1, 2]. It is not well understood how the process of marine sediment burial influences the number of cells at depth producing methane, the rate at which methanogenesis occurs, or the depth at which cellular life cannot live beyond. We begin to illuminate the complex relationship between marine sediments and the microbial life living within them by laboratory simulation of in-situ marine sediment burial conditions. We simulated natural burial and compaction of a sample to an equivalent depth of approximately 45 meters below the sea floor (mbsf) by incrementally increasing the stress on the sample at regular intervals. The sample was comprised of a well-characterized natural marine sediment, Boston Blue Clay, that was inoculated with *Shewanella* sp. cells, chosen for their easy cultivation in the laboratory. Cell density decreased from 1.5×10^8 cells g⁻¹ to approximately 1.1×10^4 g⁻¹ after the experimental compaction to 45 mbsf. Additionally, cells were visibly smaller under microscopic observation than those that had not undergone compaction. We plan to apply this method to methanogens in the future to capture the response in cell numbers and rate of methanogenesis at different effective seafloor depths. The influence of sediment compaction on cellular life in deep marine settings could further our understanding of the processes by which methane is organically produced at depth. Additionally, this information could advance our knowledge of the environmental limitations that restrict microbial life both on our planet as well as other extraterrestrial settings. [1] Park, J., & Santamarina, J. C. (2020). The critical role of pore size on depth-dependent microbial cell counts in sediments. *Scientific reports*, 10(1), 1-7. [2] Rebata-Landa, V., & Santamarina, J. C. (2006). Mechanical limits to microbial activity in deep sediments. *Geochemistry, Geophysics, Geosystems*, 7(11).

Keywords: Methanogenesis, sediment burial and compaction, environmental limitations, microbial life

SETP

ECG

Sediment dispersal and source-to-sink dynamics in active foreland river systems of the Oriente Basin, Ecuador*Claudia Banks**Banks, C., The University of Texas at Austin, Austin, TX**Horton, B., The University of Texas at Austin, Austin, TX**Jackson, L., The University of Wyoming, Laramie, WY**Vallejo, C., Escuela Politécnica Nacional, Quito, Ecuador*

Provenance analyses of active river systems provide insights into the propagation of detrital signals from source to sink. In South America, many questions remain regarding the signals from the modern Andes that successfully make it into the distal foreland and ultimately to the Amazon fan. As one of the largest tributaries of the Amazon River, the Napo River catchment includes several retroarc regions of Ecuador. Detrital zircon U-Pb geochronological analyses for 14 river sand samples from the Napo River and its tributaries (Rio Cosanga, Rio Quijos, Rio Coca) in the Eastern Cordillera, Subandean Zone, and Oriente foreland basin of Ecuador provide insights on sediment mixing and downstream variations in provenance signals.

Rock units in the Napo watershed consist of Cretaceous – Cenozoic sedimentary rocks, Jurassic – Triassic igneous rocks, and Paleozoic metasedimentary rocks. Major populations seen in age distributions for Napo River and tributary samples include Jurassic – Triassic, Proterozoic, and minor Cretaceous and Neogene. Sample age distributions display two general modes: (1) Samples dominated by Triassic – Jurassic ages have catchment areas containing large proportions of Triassic – Jurassic igneous rocks, suggesting that contributions from these units largely dictate the age distributions. (2) Samples dominated by Proterozoic ages tend to feature Cretaceous units in their individual watersheds, suggesting that Proterozoic zircons originally derived from cratonic provinces to the east may be presently eroding from Cretaceous sediments within the Napo watershed. The most distal sample from the Napo River records the integrated signal of the tributaries and has an age distribution that reflects mixed proportions of age populations in the two modes. These signals that successfully make it to the foreland may potentially feed into the Amazon and even the Amazon Fan.

Keywords: geochronology, source-to-sink, Ecuador, sedimentology, zircon

SETP
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Real-time and Data-Driven Ground Motion Prediction Equations for Earthquake Early Warning

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The ShakeAlert earthquake early warning system characterizes earthquake source locations and magnitudes in real time, issuing public alerts for areas where predicted ground motion intensities exceed a threshold value. While rapid source characterization methods have attracted a lot of attention in recent years, the ground motion models used by ShakeAlert have received significantly less. Since there are large uncertainties in earthquake source estimation, there is an immediate need for a flexible and EEW-tailored ground-motion model. This study seeks to develop data-driven framework for EEW-specific ground-motion models by precomputing and incorporating site-specific corrections while using a Bayesian approach to estimate event-specific corrections in real time. The study involves analyzing 300,000 seismic recordings from ~1500 events ($3 < M < 8$) from the entire state of California, 2011 and onwards. This approach will enable the development of a novel ground motion prediction module that can automatically correct for inaccuracies in the earthquake source estimations as well as account for higher-order source features such as seismic stress drop. Not only will prediction uncertainties likely be decreased, but they can be tracked in real time so that they may be considered directly in ShakeAlert's alerting decision.

Keywords: Earthquake Early Warning, Ground-Motion, ShakeAlert

SETP

ECG

Investigating Plate Driving Forces in Plate Reconstruction Models using pyGPlates*Edward Clennett**Clennett, E., Department of Geological Sciences & Institute for Geophysics, The University of Texas at Austin, Austin, TX**Becker, T., Department of Geological Sciences & Institute for Geophysics, The University of Texas at Austin, Austin, TX**Holt, A., Rosenstiel School of Marine and Atmospheric Sciences, University of Miami, Miami, FL**Tetley, M., Institute for Geophysics, The University of Texas at Austin, Austin, TX**Faccenna, C., Department of Geological Sciences, The University of Texas at Austin, Austin, TX;**Dipartimento Scienze, Università Roma Tre, Rome, Italy; GFZ Helmholtz Centre Potsdam, German Research Centre for Geosciences, Potsdam, Germany*

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. Modern plate reconstructions are based on a range of geophysical and geological constraints, yet are completely independent of plate driving forces, such as slab pull, ridge push and mantle flow. At present-day, slab pull is thought to be the most important force, accounting for 90% of the plate driving forces. However, the importance of slab pull and other forces in the past is less well constrained. The recent publication of a number of continuously closed plate models using the software, *GPlates*, allows for the systematic analysis of plate driving forces through time. Using *pyGPlates*, we compute net slab pull, slab bending and ridge push and mantle drag forces at 1 Myr intervals for different plate reconstruction models and compare the magnitude and orientation of these forces with plate velocity vectors. The misfits indicate how consistent the plate reconstruction model is with plate driving forces, and provides a method of comparing and assessing different plate motion models. We find that all analysed plate reconstruction models have times where there is a significant misfit between plate driving forces and plate motion vectors. This indicates where plate reconstructions could be improved, or might imply shortcomings of the assumptions on plate driving forces or the neglect of plate coupling. In particular, we find that prior to the Hawaiian-Emperor bend at ~47 Ma, the motion of the Pacific plate is inconsistent with the expected direction from plate driving forces calculated from reconstructed boundaries, and so further investigation of the plate configuration at this time period is required.

Keywords: Plate Tectonics, Plate Motion, Plate Driving Forces, Geodynamics

SETP

ECG

Ca Isotopes as Fluid Tracers during Rodingitization*Eve Hostettler**Hostettler, E., Jackson School of Geosciences, The University of Texas at Austin**Barnes, J., Jackson School of Geosciences, The University of Texas at Austin**Lassiter, J., Jackson School of Geosciences, The University of Texas at Austin**Satoski, A., Jackson School of Geosciences, The University of Texas at Austin**Starr, P., Department of Earth & Environmental Sciences, Boston College**Dragovic, B., School of the Earth, Ocean, & Environment, University of South Carolina**Baxter, E., Department of Earth & Environmental Sciences, Boston College*

The Ca isotopic compositions ($\delta^{44/40}\text{Ca}_{\text{SRM915a}}$) of rodingites from the Western Ligurian Alps are reported as preliminary data. Rodingites are Ca-rich, Si-poor rocks that form when fluids modified by ultramafic lithologies interact with mafic rocks. The existing Ca isotope data on rodingites are from one paper, which found that a sample from an obducted ophiolite reflects a mantle isotopic signature ($0.82 \pm 0.1\%$). Ca and Sr isotope data from mineral separates and associated ultramafic rocks were similar to average mantle values, which is defined as 0.8-1.1%. These data led to the conclusion that the rodingite formed as Ca was internally redistributed between the ultramafic and mafic lithologies. Therefore, rodingites do not have a direct impact on the global Ca cycle. However, these preliminary $\delta^{44/40}\text{Ca}_{\text{grt}}$ data suggest an input of seawater with a value of $1.39 \pm 0.10\%$ from an obducted rodingite (Northern Apennines). In addition, two meta-rodingites from the Voltri Ophiolite that experienced eclogite-facies conditions have $\delta^{44/40}\text{Ca}_{\text{grt}}$ values of $1.74 \pm 0.06\%$ in a garnetite vein and $2.45 \pm 4e^{-3}\%$ from the Erro-Tobbio unit. The last value is noteworthy since previous studies predicted $\delta^{44}\text{Ca}$ equilibrium fractionations between minerals are $\sim 0.8\%$ at 900°C and decrease to 0.6% at 1100°C . Inter-mineral ($\Delta^{44}\text{Ca}_{\text{grt-min}}$) fractionation in high temperature rocks is explored to investigate the significant fractionation from mantle values as seen in these Alpine rodingites. A correlation between $\Delta^{44}\text{Ca}_{\text{grt-cpx}}$ and garnet Mg# suggests that the heavy $\delta^{44}\text{Ca}_{\text{grt}}$ values could be related to the low garnet Mg# in these samples as well as having interacted with an isotopically heavy fluid during rodingitization.

Keywords: Ca isotopes, Western Alps, rodingites, fluid-rock, high-temperature fractionation

SETP

ECG

Detrital zircon ages of Pennsylvanian-Permian units in the Sacramento Mountains, New Mexico: provenance analysis in the Orogrande Basin*Sandra Juarez Zuniga**Juarez-Zuñiga, S., Jackson School of Geosciences, The University of Texas at Austin, Austin, TX**Stockli, D., Jackson School of Geosciences, The University of Texas at Austin, Austin, TX**Lawton, T., Bureau of Economic Geology, The University of Texas at Austin, Austin, TX**Kerans, C., Jackson School of Geosciences, The University of Texas at Austin, Austin, TX*

The paleogeography of southern Laurentia in the late Paleozoic was controlled by the deformation occurred in the Ancestral Rocky Mountains province (ARM) and the diachronous continental collision that formed the Marathon-Ouachita orogenic belt. The temporal overlapping of those provinces and the truncation of the southernmost Laurentia margin have led to different interpretations of the tectonic evolution of southwestern Laurentia in the time of Pangea accretion. The Orogrande basin is one of the southernmost ARM basins that preserves the geologic record of southern North America during the Pennsylvanian-early Permian; however, previous studies using detrital geochronology have focused only on the classical northern ARM basin and the Permian basin of west Texas, but the provenance sources of the Orogrande Basin as well as the timing of deformation in this region have been poorly addressed. In order to document the interplay between the ARM and the Marathon-Ouachita orogen in the Orogrande basin, in this study I present preliminary U-Pb detrital zircon data from upper Paleozoic units exposed in the Sacramento Mountains, New Mexico. I will discuss the main sediment sources and transport routing as well as the tectonic implication for the ARM deformation. The samples are sandstones and siltstones belonging to the Gobbler, Holder, Bursum and Abo formations. It is expected to observe a shift in the detrital patterns related to the unroofing of the Pedernal uplift and rerouting of sediments in the Pennsylvanian units. The subsequent cessation of deformation and the influence from the Marathon-Ouachita collisional front may be recorded in the Permian units.

Keywords: Ancestral Rocky Mountains, detrital zircon geochronology, Orogrande basin

SETP

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Detrital zircon provenance of Paleozoic strata in the Falkland (Malvinas) Islands: Implications for basin evolution and Gondwanan reconstructions*Joshua Malone**Malone, J., Department of Geological Sciences and Institute for Geophysics, Jackson School of Geosciences, University of Texas at Austin, Austin, TX, USA**Horton, B., Department of Geological Sciences and Institute for Geophysics, Jackson School of Geosciences, University of Texas at Austin, Austin, TX, USA**Dalziel, I., Department of Geological Sciences and Institute for Geophysics, Jackson School of Geosciences, University of Texas at Austin, Austin, TX, USA**Padilla, R., Department of Geological Sciences and Institute for Geophysics, Jackson School of Geosciences, University of Texas at Austin, Austin, TX, USA*

New U-Pb geochronological, Hf isotopic, heavy mineral, and sandstone petrographic results for Paleozoic strata of the Falkland (Malvinas) Islands help address renewed debates on the plate tectonic history, regional paleogeography, and basin evolution of this enigmatic feature prior to Mesozoic breakup of Gondwana. Whereas the Falkland (Malvinas) Islands have long been considered an independent microplate that originated along the eastern Cape Fold Belt of south Africa, recent geochronological, isotopic, and structural data allow the possibility of a fixed position within the broader submarine Falkland Plateau adjacent to eastern South America. New geochronologic, isotopic and sandstone petrologic data coupled with heavy mineral data reveal a shift in provenance from the Silurian-Devonian West Falkland Group to the Carboniferous-Permian Lafonia Group. We report detrital zircon results ($n = 1306$ U-Pb LA-ICPMS ages) for 11 sandstone samples from the West Falkland Group ($N=7$, $n=837$) and Lafonia Group ($N=4$, $n=469$). Detrital zircon age distributions for the West Falkland Group point to similar contributions from Neoproterozoic-Cambrian (650-520 Ma) and Mesoproterozoic (1100-1000 Ma) sources. Heavy mineral assemblages and sandstone petrographic data from these samples indicate significant input from recycled sediments. A potential shift in sediment sources during Lafonia deposition is indicated by the appearance of late Paleozoic (350-250 Ma) and Proterozoic (2000-1200 Ma) age populations, increased proportions of stable heavy minerals, and a shift to juvenile Hf values for <300 Ma zircons. The provenance change can be attributed to the onset of subduction-related arc magmatism and potential retroarc shortening and crustal thickening in southwestern Gondwana during the Late Carboniferous to Early Permian. The detrital zircon age distributions identified here reflect potential source regions in southern Africa and/or the Transantarctic Mountains in Antarctica, with southernmost South America (Patagonia) as a possible minor contributor during Paleozoic evolution of a passive margin that transitioned into a foreland basin that included the Malvinas (Falkland) Islands.

Keywords: Zircon, Hafnium, Provenance, Gondwana, Basin Evolution

SETP

ECG

Early to middle Cenozoic sedimentary response to flat slab subduction in the Middle Magdalena Basin and Llanos Basin, Colombia*Juan Gutiérrez**Gutiérrez, J., Department of Geological Sciences, University of Texas at Austin, Austin, TX, USA**Horton, B., Department of Geological Sciences and Institute for Geophysics, Jackson School of Geosciences, University of Texas at Austin, Austin, TX, USA**Gómez, S., Universidade de São Paulo**Parra, M., Universidade de São Paulo*

The Northern Andes of Colombia provide a unique configuration in which a zone of active flat-slab subduction is situated next to a zone with normal subduction. Comparison of the sedimentary records in the two contrasting areas will enable a better understanding of the role of subduction shallowing on basin subsidence, basin-margin uplift, sediment routing, and drainage reorganization due to regional tilting and local uplift of drainage barriers. In contrast to conventional subduction, models of flat-slab subduction offer conflicting predictions for basin evolution—including accelerated subsidence, cessation of subsidence, or inboard advance of subsidence. These different scenarios yield different paleogeographic histories, with rerouting of river drainage systems in response to structural partitioning of the original foreland basin into smaller “broken” basins. This study will utilize detrital zircon U-Pb geochronological analyses of Neogene basin fill in proximal (Magdalena Valley) and distal (Llanos Basin) localities to constrain the temporal and spatial evolution of sediment sources in the Eastern Cordillera. Additional paleocurrent measurements and petrographic analysis will be integrated with published thermochronological and structural reconstructions to define the transition to “broken” foreland conditions. These assessments will address both the normal and flat-slab segments, in order to evaluate the role of slab dip on paleogeography, exhumation, total bedrock erosion, as well as sediment dispersal and accumulation in the adjacent basins. The regional reconstruction will provide invaluable information for hydrocarbon exploration in Colombia and similar areas affected by shifts in deformation, exhumation, heat flow, and sediment accumulation in relationship to the geodynamics of flat-slab subduction.

Keywords: basin, flat-slab subduction, Andes, foreland

SHP

ECG

Microplastics in Texas Bays*William Bailey**Bailey, W., Jackson School of Geosciences, The University of Texas at Austin, Austin, TX**Olariu, C., Jackson School of Geosciences, The University of Texas at Austin, Austin, TX**Mohrig, D., Jackson School of Geosciences, The University of Texas at Austin, Austin, TX*

Microplastics (MP), defined as plastic particles sized between 1 μm 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/cm^3) and natural sediment (ca. 1.7-3.0 g/cm^3), MPs are hydraulically equivalent to silt- and claysized 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.

In 2021, the sampling campaign commenced, covering three large Texas bays (i.e., San Antonio, Matagorda, and East Matagorda bays), yielding approximately 100 sediment grabs and push cores located throughout the bays. 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

SHP

ECG

Lithologic Controls on Landscape Evolution: Modeling how the Cover Effect Influences Effective Erodibility*Grace Guryan**Guryan, G., Department of Geological Sciences, The University of Texas at Austin, Austin, TX**Johnson, J., Department of Geological Sciences, The University of Texas at Austin, Austin, TX**Gasparini, N., Department of Earth and Environmental Sciences, Tulane University, New Orleans, LA*

Lithology influences river channel morphology in two main ways: by setting the substrate erodibility and by producing sediment. Recent landscape evolution modeling work has explored the dynamics of rivers incising through layered strata with contrasting erodibilities using the detachment-limited stream power incision model, which offers a predictable relationship between channel steepness and erodibility, allowing us to backcalculate erodibility based on channel slope and erosion rates. In layered settings, lithologic contrasts create spatial and temporal variations in erosion rates that complicate this relationship. Furthermore, the detachment-limited model does not account for the role of sediment, which can inhibit erosion by armoring the channel bed (the cover effect), complicating the relationship between steepness and erodibility. This work explores how feedbacks between erosion and sediment production in landscapes with lithologic contrasts influence channel morphology.

The recently developed Stream Power with Alluvium Conservation and Entrainment (SPACE) model allows for the simultaneous treatment of bedrock, fully alluvial, and mixed bedrock-alluvial channels and transitions smoothly between detachment- and transport-limited behaviors. Here, we use the SPACE model to explore how sediment load influences effective erodibility in layered landscapes with lithologic contrasts. We use the Landlab Toolkit, a python-based library for modeling earth surface processes, to simulate fluvial incision through horizontally layered strata using the SPACE model. We compare models of detachment-limited and mixed bedrock-alluvial incision through alternating horizontal layers of hard and soft rock, motivated by the lithologic variability found in the Guadalupe Mountains of Texas and New Mexico. We explore how sediment modulates the topographic expression of rock properties in mixed bedrock-alluvial rivers incising through horizontally layered rocks by comparing channel steepness, sediment fluxes, and erosion rates through space and time.

Keywords: fluvial geomorphology, landscape evolution modeling

SHP

ECG

Characterizing Rayleigh Taylor Instability and Convection in a Porous Medium with Geoelectric Monitoring*Neelarun Mukherjee**Mukherjee, N., Jackson School of Geosciences, The University of Texas at Austin, Austin, TX**Dhar, J., Université du Luxembourg, Department of Physics and Materials Science, Luxembourg, Luxembourg,**Jougnot, D., Sorbonne Université, UMR 7619 METIS, Paris, France**Meheust, Y., Université Rennes 1, Rennes, France*

The use of geophysical tools for subsurface characterization is a common practice in environmental studies and georesources engineering. The electrical conductivity of the subsurface is strongly influenced by the different properties of the subsurface such as pore fluid chemistry, and consequently, by subsurface processes that affect the spatial distribution of that chemistry, such as the mixing dynamics of pore fluids. In the context of freshwater-saline water interaction in coastal areas, changes in solute spatial distribution are coupled to density-driven flow, which can thus be monitored via geoelectrical measurements. Here, we study the Rayleigh Taylor instability and subsequent convection occurring due to the density difference between two miscible liquids when the lighter one is positioned on top of the denser one, a configuration that is relevant for saltwater-freshwater interactions in coastal aquifers. We simulate the convective process and monitor it numerically by computing the transverse apparent conductivity of the medium in time, as the convection develops. We then look for correlations between the geoelectrical signal and a global scalar measure of the convective process' advancement, namely the variance of the solute concentration field.

Keywords: Hydrogeophysics, Hydrology, Geophysics, Computational Fluid Dynamics

SHP

ECG

Groundwater-surface water interactions in seasonally and tidally flooded riverbanks: numerical modeling of the Meghna River, Bangladesh*William Nguyen**Nguyen, W., Department of Geological Sciences, The University of Texas at Austin, Austin, TX**Cardenas, M., Department of Geological Sciences, The University of Texas at Austin, Austin, TX**Datta, S., Department of Geological Sciences, The University of Texas at San Antonio, San Antonio, TX**Kwak, K., Department of Geology & Geophysics, Texas A&M University, College Station, TX**Varnier, T., Department of Geological Sciences, The University of Texas at San Antonio, San Antonio, TX**Demir, C., Department of Geological Sciences, The University of Texas at Austin, Austin, TX**Pedrazas, M., Department of Geological Sciences, The University of Texas at Austin, Austin, TX**Knappett, P., Department of Geology & Geophysics, Texas A&M University, College Station, TX*

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 (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 iron- 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 a conservative solute transport 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: Arsenic, Hyporheic, Groundwater, Modeling, Tides

SHP
ECG

Characterizing short-term alluvial river bank erosion patterns with time-lapse airborne lidar and UAV-derived structure-from-motion topography data

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Lowland alluvial river channels naturally migrate. Long-term channel migration is modeled to scale with bend curvature—a channel is represented as a line with constant width and sharply curved river bends are predicted to have the highest lateral migration rates. However, field and remotely sensed data show that channel width in many rivers is dynamic, with bends that widen and narrow in response to individual storms. This project examines bank erosion along the rapidly migrating Trinity River near Houston, TX using three airborne lidar surveys (from 2011, 2015, and 2018) and four UAV surveys of channel cut banks (from 2021) to understand short-term alluvial channel migration patterns. The Trinity’s floodplains are composed of a heavily vegetated bottomland hardwood forest and there is extensive visual evidence that live tree roots and fallen tree debris are influencing bank failure processes. Through time-lapse topographic differencing, we map the location and timing of bank erosion events along four river bends. We apply the curvature-dependent migration model to our topographic data and compare the model results with mapped erosion patterns. We also analyze correlations between erosion volumes and the scale and distribution of bank roughness, which we hypothesize could exert a primary control on local erosion patterns. This project has applications to the design of natural channel modifications to increase channel stability, including potentially effective uses of vegetation for biotechnical erosion control. It also begins to interrogate what the feedback processes are that make curvature a good predictor of lateral channel migration over longer time scales.

Keywords: river migration, time-lapse lidar, UAV mapping, river bank erosion

Elastic Properties and Permeabilities of Hikurangi Margin Rocks as a Function of Stress, Saturation, and the Presence of Fractures*Carolyn Bland**Bland, C., University of Texas at Austin**Tisato, N., University of Texas at Austin**Van Avendonk, H., University of Texas Institute for Geophysics**Bangs, N., University of Texas Institute for Geophysics**Gase, A., University of Texas at Austin*

Stress, saturation, and the presence of fractures impact the elastic properties and permeability of rocks. The Hikurangi margin of New Zealand displays different fault slip behavior, with a transition from aseismic creep in the north to coseismic slip in the south. The different modes of slip along the margin may be related to different rock physical properties. For example, impermeable clay-rich mudstones might contribute to the generation of fluid overpressures at depth. We perform geomechanical experiments on outcrop samples from the Raukumara Peninsula region to explore how the elastic behavior and permeability of Hikurangi margin mudstones vary with terrane and confining pressure. In particular, we present data for Miocene-aged mudstones, which represent recently accreted sediments forming the outer prism, as well as Early Cretaceous mudstones that are analogous to the inner prism. We use a NER AutoLab 1500 pressure vessel equipped with a saturation fluid circuit to generate a range of confining pressures and to saturate the mudstone samples. We measure shear and compressional velocities for confining pressures ranging 0-200 MPa for dry and saturated samples. Testing on three samples gave V_p/V_s ranging from ~ 1.5 to ~ 2.0 . Using Gassmann's model for fluid substitution, the compressional and shear velocities for the saturated core were predicted and compared with the measured values. The modeled compressional velocities agreed with the measured velocities; however, the model underestimated the shear velocities. Current work involves measuring the permeability of intact and fractured clay-bearing mudstones using the transient method. The effect of fractures on mudstone elastic properties is also examined. Low permeability estimates for one mudstone sample suggest the studied lithology would be capable of acting as an impermeable barrier and influencing overpressures at depth. This experimental framework will be applied to additional rocks from the Hikurangi margin. Ultimately, these results will help constrain the hydraulic conductivity of the overriding plate, mechanisms of overpressure generation, and the influence of fluid pressures on seismic velocities.

Keywords: Elastic Properties, Permeability, Subduction, Stress, Saturation, Fractures

LCMS

Fluid-mobile element cycling through the forearc of Costa Rica*Jacob Helper**Helper, J., Department of Geological Sciences, The University of Texas at Austin, Austin, TX**Barnes, J.D., Department of Geological Sciences, The University of Texas at Austin, Austin, TX**DeMoor, J.M., OVSICORI, Universidad Nacional de Costa Rica**Rodriguez-Bodilla, A., OVSICORI, Universidad Nacional de Costa Rica*

Freshwater springs are common in the forearc of convergent margins, and Costa Rica has an unknown number of springs scattered across the country. Few sites around the world are known to have subaerial springs in the forearc of a convergent margin. The uplift of the Nicoya, Santa Elena, and Osa peninsulas has allowed subaerial springs that would otherwise be submarine. The juxtaposition between these springs and the subduction zone beneath presents an opportunity to study fluids originating from intermediate to potentially great depths (50-200km). The hydrogeological properties of the Costa Rican subduction zone influence the presence of seismicity, fault mechanics, and magma production along the margin. Understanding the origin and pathway of fluids in the forearc will help improve understanding of the features, and advance knowledge of global element cycling between the crust and the mantle. Using fluid-mobile elements (Cl, Br, I, B, and Li) to trace fluids in convergent margins has been well established, but previous studies have often overlooked the forearc. Describing fluid loss in the forearc is difficult for several reasons including differences in pathways due to faulting, and variability in the depth in which fluids are released. Seepage through the accretionary prism and incorporation into arc magmas are the primary outputs for fluids to leave the convergent margin; however, poor characterization of fluid-mobile element loss through the forearc has made it difficult to develop mass balance models and flux calculations.

This study focuses on freshwater springs dominantly located in northwest Costa Rica. Based on isotopic signatures and geochemical analysis, three different settings are being associated with the locations of these springs: the volcanic arc, the forearc, and the outer forearc. The difference between these localities is often well defined geochemically allowing for fluid sourcing to be theorized efficiently. The presence of known faults and differences in host lithology is identified and discussed as a key component in the alteration of spring geochemistry as well.

Keywords: isotope, geochemistry, costa rica, forearc, springs

CCG
LCMS

Modeling the Ecosystem Services Impacts of Renewable Energy Development Via a Risk Assessment Framework

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Decarbonization of the electrical grid is a key strategy to achieve carbon neutrality by 2050 or sooner, a common benchmark for climate change policies. In the United States, low-carbon electricity capacity expansion via new utility-scale wind and solar developments will require substantial tracts of land, particularly in the central “wind belt” and across the western US. This development will impart some opportunity costs and pose risks to other ecosystem services, including biodiversity, soil carbon storage, and cultural heritages that are tied to land quality. These services are not a traditional consideration in siting decisions, except to the extent that they are represented by other suitability factors, or identified in an ad hoc manner by land owners or stakeholders.

Using the Trans-Pecos Texas region of Texas as a case study, we propose a risk assessment framework for evaluating and mitigating the effects of renewable energy development on ecosystem services. The framework uses remotely sensed datasets, local and regional knowledge of conservation values, and future development scenarios, all of which are synthesized using the Habitat Quality and Habitat Risk Assessment models from the Natural Capital InVEST software suite. We then model ecosystem service quality, vulnerability, and risk vis-a-vis both extant and projected energy development, and assess the trade-offs between the positive benefits of energy development and negative impacts to land quality. Results show how relocating electricity generating facilities and support infrastructure, in some cases by less than 5 km, can substantially mitigate impacts to landscapes with higher ecosystem service valuations, while preserving the ability of land owners (and electricity consumers) to benefit from the siting of new facilities. We demonstrate that land use models that account for ecosystem services can be included in more holistic siting and permitting processes, ideally yielding improved environmental outcomes and optimal siting of energy infrastructure.

Keywords: renewable energy, wind energy, solar energy, ecosystem services, land use change, sustainable land use

CCG
LCMS

The cobalt supply chain and life cycle assessment of lithium-ion battery energy storage systems

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Lithium-ion batteries (LIBs) deployed in electric vehicles (EVs) and energy storage systems (ESS) can reduce the carbon intensity of the transportation and electricity sectors. To meet global greenhouse gas (GHG) reduction goals, LIB demand is likely to continue to grow, requiring additional raw materials to manufacture the batteries. While the operation of LIBs has limited environmental impacts, the impacts of the upstream processes needed to convert raw materials into battery components are not fully understood. The focus of this work is the cobalt supply chain, a crucial component in many types of LIB. The aim of this study is to quantify the cradle-to-grave global warming potential (GWP), acidification potential (AP), eutrophication potential (EP), photochemical oxidant creation potential (POCP), particulate matter (PM), ecotoxicity, land use, and water use attributed to the mining, extraction, refining, and incorporation of cobalt products into a LIB. Multiple cobalt production routes are compared to account for regional variability in life cycle impacts. Two of the most common cobalt bearing LIB cathode chemistries, nickel-cobalt-aluminum oxide (NCA) and nickel-manganese-cobalt oxide (NMC) are included in this investigation. The life cycle cobalt requirement and associated impacts are compared between wind and solar electricity generation with ESS. This research uses openLCA, a life-cycle and sustainability assessment software, to calculate impacts from supply chain process data collected from an extensive literature review and publicly available industry reports. Background process data is sourced from the ecoinvent life cycle inventory database. The results shed light on which processes in the LIB cobalt supply chain are most environmentally impactful, how these impacts vary regionally, and the relative cobalt intensity of wind and solar electricity generation when combined with ESS. This research will help battery manufacturers optimize cobalt supply chain processes to reduce environmental burdens of LIBs. Policy makers and the private sector can use this work to identify locations to direct further investment.

Keywords: Life Cycle Assessment, supply chain, batteries, cobalt, energy storage

EG
LCMS

Shortest Path Based Multiple Well Log Correlation

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Well log correlation matches log samples from different wells to a common geologic time, thus removing the spatial variations associated with structural and stratigraphic variations and allowing us to extrapolate the petrophysical information to larger volumes. Automatic methods for well log correlation are preferred over manual correlations for two main reasons. The first is the inherent subjectivity of a manual correlation. The second is 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 approaches are less computationally demanding; however, they are susceptible to error propagation and the final error depends on the correlation sequence used for the correlation. Unfortunately, the number of potential correlation sequences can be as high as $n!$, n being the total number of wells to be correlated, making it very difficult to assess the quality of every possible correlation sequence.

We propose the use of a workflow for correlating multiple well logs, based on following sequences computed by the Dijkstra's shortest path method and using either shifted plane wave destruction filters or local similarity scans for shift estimation. We expect the first part of this method to be a hybrid between sequential and simultaneous multiple well log correlation, being a more lightweight alternative to simultaneous correlation and more robust than simple sequential correlation.

Keywords: data matching, well log correlation

EG
LCMS

3D Interpretation, Structural Characterization, and Seismogenic Association of Faults in the Eagle Ford Region, south-central Texas

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The Eagle Ford shale play of south-central Texas experienced an increase in the rate of felt seismicity from 2014-2019, temporally coincident with unconventional petroleum development. By mid-2019, the rate of seismicity decreased alongside the reduction of well completion rate, thus prompting a drive to better understand the relationship between hydraulic fracturing operations and geologic conditions that contribute to fault rupture.

Goals of this work include mapping and geomechanical characterization of faults that delineate seismogenic regions, such as the Karnes fault zone, as well as aseismogenic regions of the Eagle Ford. A regional, integrated data set composed of published data, wells, earthquakes, and interpretations from operators provides input for a 3D structural framework. Moment tensor and earthquake relocation analyses provide insights into the distribution of earthquakes that correlate to fault planes and thereby enable identification of seismogenic faults. In-situ stress state of faults was analyzed to determine fault sensitivity for both 2D and 3D applications. A spatiotemporal analysis of hydraulic fracture operations and earthquakes identified induced earthquake clusters.

Faulting mapped across the Eagle Ford trend is dominated by NE-SW striking normal faults, regional faults dipping towards the SE, and counter-regional faults dipping towards the NW. In total, 16% of faults have hosted induced earthquakes from 2017-present. Faults in the Eagle Ford have a geologically quasi-stable in situ stress state, with ~36% of faults requiring ≤ 2 MPa of pore pressure increase to slip. Using a conservative scheme, we directly associate 46% of earthquake ruptures to hydraulic fracturing to build our analysis dataset. 71% of those events are spatially located within 1km of a known mapped fault. Specifically, 78% of induced earthquakes are located within the Karnes trough. Stress conditions on faults located within 1km of induced earthquakes have similar rupture sensitivity to the rest of the population. This suggests that faults close to hydraulic fracture operations must be considered hazardous.

Keywords: Induced Earthquakes, Structural Geology

MG
LCMS

A Modern Distribution of Foraminifera to Reconstruct Environmental Change Offshore Galveston Bay, Texas

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Sand is an important resource for coastal engineering, but in Texas, offshore sand deposits are primarily found buried in fluvial deposits, bayhead, flood, ebb tide deltas, or within tidal channels. Exploring for these resources requires a comprehensive understanding of the depositional system. This project examines the environmental evolution of the Trinity river valley estuary using benthic foraminifera and core data. These modern day assemblages of foraminifera are compared with core data to understand how the system has evolved over time. 32 grab samples were collected offshore Galveston Bay and were stained with rose bengal to identify the living or recently living benthic foraminifera. 300 individual foraminifera were identified to the species level, and their distributions was mapped across the inner continental shelf, and compared to the most recent survey, which was in the late 1940s. Additionally, seafloor samples on the inner shelf will improve our understanding of how shelf ecology has changed due to anthropogenic effects over the last 80 years. Observing the modern assemblage of inner shelf species is also necessary to determine whether fossil assemblages in the cores in the study area represent estuarine or offshore deposits, which will help determine whether core material was deposited by estuarine processes inside the bay or in the ebb tidal delta on the open shelf.

Keywords: Marine geology, paleoenvironmental reconstructions, foraminifera, micropaleontology

MG
LCMS

Paleogeographic evolution of the Orange and Green sands in WR 313, Deep-water Gulf of Mexico

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We use 3D seismic and well log data to interpret the paleogeographic evolution of hydrate-bearing reservoirs in Walker Ridge Block 313, deep-water Gulf of Mexico. The study area is within the Terrebonne Basin, a saltconfined mini-basin, where we interpret a channel-levee system that influenced the deposition of two hydratebearing reservoirs: the Green and Orange sands. First, we focus on the Green sand. Three horizons were mapped to determine the timeline of channelization and deposition and are referred to as the Green interval: the Sub-Green horizon (predates channelization), the Base Green horizon (records the onset of channel activity), and the Top Green horizon (equivalent to the top of the Green sand). The Top Green horizon is the uppermost horizon and is mapped as a prominent regional reflector that marked the final leg of deposition within the Green interval. Second, we focus on the Orange Sand. The Orange sand is mapped as a regional reflector that flanks both sides of the channel. The channel was oriented NW-SE and flowed towards the SE where salt-related uplift took place. The levees are thicker on the southwest flank of the channel compared to the northeast flank. The H well penetrated the levee deposits on the northeast flank of the channel. The GR log and Resistivity logs from the H well record two coarsening upward signatures several feet apart which we interpret at the Green sand and the Orange sand, respectively. The density and velocity logs from the H well confirm the presence of methane hydrate in the Orange sand. The levees onlap the salt on the southwest side of the basin. Salt confinement in conjunction with greater basin subsidence due to salt withdrawal on the southwest edge could result in thicker levees on the southwest flank of the channel compared to the northeast flank. This study shows how seismic stratigraphy of channel elements can be used to understand the evolution of a deep-water channel-levee system containing hydrate-bearing sands.

Keywords: channel-levee system, Deep-water Gulf of Mexico, methane hydrates

PS

LCMS

Volcanic Facies and 15m Roughness Throughout Athabasca Valles Lava System: A Multi-Stage Flow Development

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We investigate the geologic evolution of the Athabasca Valles Lava System to determine the spatial and temporal relationships between facies, with the support of geomorphic mapping and Radar Statistical Reconnaissance analyses. The striking juxtaposition of fluvial, lava-ice, and volcanic features have drawn the attention of several studies with a broad spectrum of interpretations as to the nature of the outflow channel materials. However, our facies map reveals that the surface of Athabasca Valles system includes seventeen distinct morphologic facies, interpreted to be the result of flood lava volcanism. The identification of meter scale surficial morphologic changes throughout the Athabasca lava system provides an opportunity to explore flow formation processes, yet to be fully illustrated. Hence, an integration of a diversity of datasets and knowledge of the outflow associated features is necessary to further the investigation into Athabasca Valles outflow emplacement processes.

We expand on the hypothesis that roughness reflects the morphologies and emplacement conditions of lavas by extracting topographic elevation measured from Mars Orbiter Laser Altimeter (MOLA, ~400m/pixel) and analyze with RSR roughness at 15m scale and facies patterns along the Athabasca flow path. The RSR measures root mean square height (RMS_h) and effective slope (S_{eff}) [°] provide sufficient resolution to recognize patterns and features consistent with the facies locale. Roughness patterns and facies localities suggest that the emplacement of Athabasca lava experienced a dynamic progression of local discharge and substrate topographic influence on morphology. There are three distinct trends in the RMS_h vs. (S_{eff}) [°] distribution: (1) where the Athabasca facies are more sensitive to variations in RMS_h (2) the surrounding geologic units are more sensitive to variations in effective slope [°] (3) and it appears that there is a transition to higher RMS_h for facies along the margins of the Athabasca flow and closer to the source, except for the VRC groups. Quantitative measures of RMS_h surface and near-surface roughness of Athabasca lava features range from 1.09m to 1.76m. The RMS_h response is consistent with facies transitions and the influence of morphology from substrate topographic features.

These initial results confirm the linkage between surficial morphologies and lava flow roughness, including the ability to constrain the spatial and temporal evolution of emplacement processes. We find that that Athabasca facies are characterized by unique roughness patterns indicative of flow states and topographic influences on morphology. Furthermore, lava flows emplaced in the northern and southern segments of our study area demonstrate that the Athabasca system underwent different stages of a single eruption. Results from 3D roughness mapping at 15m scale with integration of SHARAD subsurface reflectors will further test and constrain the spatial and temporal relationship between morphology and roughness, as well as provide additional insight into the formation processes involved in recent Martian outflow channels.

Keywords: Planetary Geophysics, Radar Statistics, Roughness Characterization, Martian Volcanism, Geological Mapping

SETP
LCMS

Stable Isotope Composition of Slave Subcontinental Lithospheric Mantle as a Tracer of Metasomatism

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The mechanisms behind the formation and stabilization of Archean crustal provinces and their underlying lithosphere are poorly understood. Three proposed models for the formation of the Archean subcontinental lithospheric mantle (SCLM) are: 1) decompression melting within a plume; 2) underthrusting and imbrication of oceanic lithosphere; and 3) subduction-related melting followed by accretion. Stable isotopes are a powerful tool for examining material fluxes between the Earth's surface and interior, and thus may provide a means of testing the above models for lithosphere formation. In particular, pairing stable isotope data with geochemical tracers of subduction can be an effective, yet underutilized, method for detecting subducted components in the mantle. Here we present oxygen isotope data for olivine, clinopyroxene, and garnet and calcium isotope data for clinopyroxene from garnet lherzolite samples from the Slave Craton, NWT, Canada. Oxygen results show the Slave SCLM has an average of $\delta^{18}\text{O}_{\text{olv}} = +5.33\text{‰}$ ($n=12$), with a range of $\delta^{18}\text{O}_{\text{olv}}$ values (+5.02 to +5.51‰). In general, $\delta^{18}\text{O}_{\text{cpx}}$ values and $\Delta^{18}\text{O}_{\text{cpx-olv}}$ are lower (average = +5.30‰ and 0.00‰, respectively) than expected equilibrium values at mantle temperatures. These low $\delta^{18}\text{O}_{\text{cpx}}$ values may suggest an added ^{16}O -enriched component. Additionally, $\delta^{18}\text{O}_{\text{grt}}$ values are lower than the expected mantle (average = + 5.28 ‰) and show a strong correlation of decreasing values with increasing H, Na_2O content and Ce/Sm in garnet, also consistent with interaction with a metasomatic fluid/melt with low $\delta^{18}\text{O}$ values. Preliminary Ca isotope data shows the Slave SCLM has an average $\delta^{44/40}\text{Ca}_{\text{cpx}} = +0.91\text{‰}$ ($n=3$). Two of the measured samples' $\delta^{44/40}\text{Ca}_{\text{cpx}}$ values are typical of the mantle ($\delta^{44/40}\text{Ca}_{\text{cpx}} = +0.96\text{‰}$ and +0.97‰) whereas one sample has a low $\delta^{44/40}\text{Ca}_{\text{cpx}} = +0.81\text{‰}$ that has consistently low $\delta^{18}\text{O}$ values in all phases ($\delta^{18}\text{O}_{\text{olv}} = +5.02\text{‰}$; $\delta^{18}\text{O}_{\text{cpx}} = +5.10\text{‰}$; $\delta^{18}\text{O}_{\text{grt}} = +5.01\text{‰}$). This low $\delta^{44/40}\text{Ca}_{\text{cpx}}$ value may further suggest this metasomatic melt/fluid interacting in the Slave SCLM is enriched in ^{40}Ca as well. Future work will expand the calcium stable isotope data set and pair with major and trace element and radiogenic data to better constrain the timing and nature of metasomatism, and thus the mode and role of subduction in the Slave SCLM formation and modification.

Keywords: Geochemical cycles, mantle processes, subduction zone processes, stable isotopes

SETP

LCMS

Dating the Western Carpathians Mountains, Slovakia near Gerlachovský štít by Zircon and Apatite (U-Th)/He Thermochronology*Daniel Campos**Campos, D., The University of Texas at Austin**Catlos, E., The University of Texas at Austin**Kohut, M., The Slovak Academy of Sciences**Broska, I., The Slovak Academy of Sciences**Stockli, D., The University of Texas at Austin*

The Carpathian Mountains form a large collisional orocline stretching from Vienna, Austria to Bucharest, Romania, and include the High Tatra mountains in northern Slovakia and southern Poland exhibiting the highest elevation peaks of the entire mountain belt. Along the southern flank, the High Tatras contain Variscan-age granites that are ideal targets for zircon and apatite (U-Th)/He thermochronometry to study the exhumation history and late-state tectonic evolution of the inner arc of the mountain belt. The zircon and apatite (U-Th)/He systems have well-constrained closure temperatures and the vertical sample array will help to reconstruct the exhumational passage of the unit through the upper crust and eventually the surface. These ages and derived cooling histories will help determine timing of activation and geometric evolution of the subTatra fault, widely considered to be the major controlling structure for the exhumation of the southern flank of the High Tatras. The goal of this study is to determine the timing during which these rocks were tectonically advected through the upper crust and through the nominal zircon (~180°C) and apatite (~65°C) He closure temperature windows. The principal sample transect for this study is near Gerlachovský štít, the topographically highest point of the High Tatra Mountains. Samples from different elevations were collected and analyzed for apatite (U-Th)/He ages (n=7; 6 aliquot ages each) and for zircon (U-Th)/He zircon ages (n=14; 3 aliquot ages each). The (U-Th)/He apatite ages increase systematically from 9.6±0.6 Ma (elevation 1750 m) to 18.8±1.2 Ma (elevation 2167 m), with one sample near the sub-Tatra fault exhibiting an older result of 30.2±2.1 Ma (elevation 1922 m). Zircon (U-Th)/He ages from the same samples, however, are more scattered due to radiation damage, and range from 15.5±1.3 Ma (elevation 1423 m) and 29.2±2.3 Ma (elevation 1983 m). These age results are in good agreement with published low-T thermochronometric results, but the apparent average exhumation rates (~0.04-0.045 mm/yr) for both zircon and apatite He data derived from the age-to-elevation profiles are inconsistent with published rapid early Miocene exhumation pulse. Our results likely capture both pre- and post-Miocene slow cooling interrupted by early Miocene tectonic unroofing. Numerical joint-sample inverse modeling will shed additional light on the detailed Cenozoic evolution of the southern flank of the High Tatras. Additionally, apatite U-Pb dating will complement the data with the aim of tracking the evolution of the High Tatra Mountains from the onset of magmatism during the Variscan orogeny to exhumation.

Keywords: (U-Th)/He Thermochronology, High Tatras, Western Carpathians

SETP

LCMS

Intrusion and cooling history of some late-tectonic Salem granites (Namibia) as deduced from U-Pb and Ar-Ar thermochronology and implications for the Damara orogeny

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The Damara orogen reflects the amalgamation of multiple cratonic blocks in the late Neoproterozoic and early Paleozoic, with its continental arm in central Namibia marking the collision of the Kalahari craton with the Congo craton. 19 samples were collected from plutons of the Salem granites within the northern Central Zone (nCZ), a tectonic unit marked by its abundance of felsic intrusions. To clarify the timing and context of these plutonic rocks, U-Pb LA-ICP-MS dating on zircons was conducted, and XRF whole-rock major- and trace-element compositions were measured. Ar-Ar biotite step-heating experiments, Ar-Ar laser-ablation measurements on amphibole, and Ar-Ar MDD modeling on K-feldspars were carried out to revise the region's post-Damara cooling history, particularly in the to-date unexplored temperature range of 150 – 350 °C. The samples are characterized by their large K-feldspar and plagioclase phenocrysts and their richness in biotite. They are classified as peraluminous, alkali-calcic to calc-alkalic, predominantly ferroan diorites, quartz monzonites, granodiorites and granites. Zircon dating revealed intrusion ages for four samples of 484.2 ± 1.9 , 486.8 ± 2.1 , 493.7 ± 1.4 and 500.5 ± 2.0 Ma. All samples therefore likely post-date the peak of metamorphism at 508 ± 11 . Concordant zircon cores, inherited from pre-Damara mountain-building phases within the Congo craton, gave ages of 1014 ± 14 , 1030 ± 12 , 1092 ± 11 , 1136 ± 11 , 616.0 ± 7.6 , 632.1 ± 6.4 and 732.9 ± 7.0 Ma. Melt formation occurred in the lower crust at pressures of >7 kbar and temperatures of 934 to 996°C, deduced from zircon saturation thermometers. Temperature conditions in the central part of the orogen were elevated due to the high level of heat-producing elements and tied to the intrusion of large volumes of igneous rocks. Initial fast cooling is reflected in Ar-Ar biotite ages ranging from 463.4 ± 2.1 to 479.7 ± 2.1 Ma and one Ar-Ar amphibole age of 479.2 ± 7.5 Ma. By 410 Ma, the nCZ had cooled down to a geothermal gradient of 19 – 20 °C/km. After a phase of tectonic stability with low erosion rates of 0.011 – 0.023 mm/a, the samples experienced an episode of increased erosion with erosion rates of 0.079 – 0.123, which for the samples in the east of the study area lasted from roughly 400 to 350 Ma and from 350 to 300 Ma for the southwestern samples. This increase is linked to a yet unidentified extensional tectonic event. Following another era with modest erosion rates, a period of tectonic activity in the late Permian and Triassic, presumably associated with the Cape orogeny near Gondwana's southern edge, exhumed the granites at a pace of 0.05 – 0.15 mm/a, exposing them to the surface by 200 Ma.

Keywords: Ar-Ar, U-Pb, thermochronology, geochronology, Namibia, Damara, geochemistry, petrology, tectonics, structural geology, orogeny, continental collision, Pan-African orogeny, MDD, Gondwana, denudation, thermal history modelling

SETP

LCMS

Tectono-metamorphic history and petrochronology of HP-LT units in Ossa and Pelion, Greece*Emily Hinshaw**Hinshaw, E., Department of Geological Sciences, The University of Texas at Austin, Austin, TX**Stockli, D., Department of Geological Sciences, The University of Texas at Austin, Austin, TX**Soukis, K., Department of Geology and Geoenvironment, National and Kapodistrian University of Athens, Athens, Greece*

In the Aegean region, the Cycladic Blueschist Unit (CBU) and Ambelakia Blueschist Unit (ABU) represent early Cenozoic subduction-related HP-LT metamorphic complexes exhumed in the back-arc of the Hellenic subduction zone. One of the largest coherent packages of blueschist-facies metamorphic rocks is exposed in the Pelion peninsula, and a second is exposed further northwest at Mt. Ossa. While these tectonic slices have been linked to each other and to the CBU further south, little is known about the tectonic affinity, structural position, or timing of metamorphism for these rocks in eastern Thessaly. Their tectonic relationship is critical for understanding the early evolution of subduction dynamics, underplating, and metamorphism in the Aegean. Typical lithologies include quartz-mica schists, commonly with intercalations of meta-carbonates or meta-basic lenses. Glaucofan-bearing HP-LT mineral assemblages are best preserved in northern Pelion, while Ossa and southern Pelion more often show retrograde greenschist-facies metamorphism. This study provides new insights into the sedimentary provenance and tectonic affinity by integrating U-Pb detrital zircon (DZ) and detrital apatite (DA) data with structural context. We also utilize metamorphic zircon rim overgrowths and apatite U-Pb geochronology to refine the timing and conditions of HP-LT metamorphism for both Ossa and Pelion.

The DZ provenance and MDA data strengthen the pre-subduction tectonic relationship between Pelion and Ossa, as do field observations of structural relationships and metamorphic grade. DZ results reveal three dominant metasedimentary provenance types, which are consistent across Ossa, Pelion, and published data from the CBU. In Ossa, the tectonic evolution is constrained by U-Pb zircon data from an overlying Carboniferous basement with Triassic granitic intrusions, and by an Eocene flysch which underlies the ABU. In Pelion, tectonic relationships are defined by U-Pb zircon data from underlying Carboniferous and Triassic basement. Depth-profiling analysis of metamorphic zircons and apatite U-Pb dating shed light on the metamorphic history of HP-LT rocks. We determine peak HP-LT metamorphism for Ossa at 54 Ma, with initial metamorphism as early as the mid-Cretaceous. Southern Pelion similarly records mid-late Cretaceous metamorphism, however northern Pelion records overgrowths from the Eocene through Oligocene. These new data show that the ABU from Ossa and Pelion are unequivocally lateral equivalents of the CBU, on the basis of stratigraphic ages, provenance signatures, tectonic affinity, and subduction metamorphism history. However, the Ossa and Pelion HP-LT rocks appear to have experienced lower peak metamorphic conditions compared to the classic CBU as indicated by metamorphic mineral assemblages, zircon rims, and apatite U-Pb thermochronometry. This study provides important new insights into the correlation of Neotethyan HP-LT subduction complexes in Greece.

Keywords: geochronology, petrochronology, subduction, metamorphism, Greece

SHP
LCMS

Reconstructing the genesis of sandy marine storm beds within the Eocene Coaledo Formation, Southwestern Oregon

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The Eocene strata of southwestern Oregon provide an opportunity to study the lateral and vertical facies changes in connected deltaic-to-shelf-to-slope deposits. We focused on exposures of the Coaledo Formation in the sea cliffs and wave-cut benches of greater Sunset Bay State Park. These deposits have long been recognized as preserving world-class examples of sandy marine storm beds, but most of the published work interpreting how these deposits formed is > 35 years old and contains little insight into how properties of these storm deposits change through space. In this study, we take advantage of recent advancements to modify and refine interpretation of the origins and depositional processes associated with the Coaledo storm deposits. We particularly focus on the degree of lateral continuity as a function of bed type and thickness, spatial changes in deposit character (thickness, grain size and sorting, sediment composition, and sedimentary structures), and interpreted sediment-transport styles. Measured sections and 3D outcrop models produced from drone images are combined with this data to reconstruct emplacement histories for these continental-shelf storm deposits and to quantify their connection to riverine channels as sediment sources.

Keywords: Deltaic deposits, Coaledo Formation, Storm beds, Lateral interpretation, 3D outcrop models

SHP
LCMS

Using stochastic estimation to better understand brackish groundwater resources in Central Texas

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Estimating recoverable groundwater volumes is crucial to Texas' state water planning process. Volume estimation is based on deterministic models, however stochastic estimation provides important context to water planners or people interested in developing brackish groundwater resources. In this study, I reprocessed an existing model of deterministic groundwater storage and salinity estimates to produce stochastic estimates for five stacked aquifers in Central Texas (the Wilcox, Carrizo, Queen City, Sparta, and Yegua aquifers). In creating the stochastic storage estimates, I used Monte Carlo Simulation to sample from spatially debiased net sand thickness distributions and literature review generated distributions of specific yield. When using the single specific yield value from the deterministic study, I found that Monte Carlo Simulation produced similar results to deterministic estimation. Spatially debiasing the net sand thickness point data increased the estimated volume on average by 3%. Specific yield values from the deterministic study were sourced from corresponding Groundwater Availability Models, which were determined for the entire aquifer thickness rather than the net sand thickness. Sampling from the literature review generated distribution of specific yield revealed the deterministic study estimates to be on average 61% of the stochastic P50 estimates. To generate stochastic estimates of groundwater salinity, I used ensemble bagging to create P10, P50, and P90 relationships between key variables and then recalculated the salinity estimates using these stochastic relationships. P50 stochastic salinity maps were largely similar to deterministic salinity maps. However, comparing P10 to P50 to P90 salinity maps reveal that finer resolution mapping and additional saline water quality samples are needed to further constrain uncertainty. Further work will involve testing how these findings affect the cost of brackish groundwater desalination.

Keywords: brackish groundwater, stochastic estimation, Texas

LCPHD

Fracture detection and property estimation in microCT images

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MicroCT imaging is a promising method when used to image experiments on rocks. Even more promising is imaging experiments on rock samples repeatedly over time, allowing for the observation of samples as the experiment progresses. Considering hydraulic conductivity as a subject of interest, particularly understanding how fracturing a rock sample under a deformation regime affects its permeability, detecting and measuring fracture properties is fundamental.

To detect and measure fracture features from microCT images in a repeatable and semi-automatic manner, it is required to produce consistent fracture property measurements of time-variant sample images. Here we evaluate and utilize a Multi-scale Hessian Fracture Filtering (MSHFF) technique (Voorn et al. 2013) on synthetic images of fractures and two-time instances of microCT images of a rock sample. We find that the MSHFF is successful in enhancing and detecting fractures. In addition, this technique mitigates the effect of beam hardening on fracture detection in microCT images of rock samples. This image enhancement increases the reliability of detecting and measuring fractures of time-varying images of a rock sample. As a result, we improved the estimate of fracture surface area due to the fracturing of a rock sample that was subject to a rotary shear experiment.

Keywords: microCT, rock properties, fractures

LCPHD

Coupling between Sedimentation and Deformation*Xinggang Liu**Liu, X., Department of Geological Sciences, The University of Texas at Austin, Austin, TX**Mohrig, D., Department of Geological Sciences, The University of Texas at Austin, Austin, TX**Buttles, J., Department of Geological Sciences, The University of Texas at Austin, Austin, TX*

This research unravels the coupling dynamics between turbidity-current sedimentation and salt deformation. Turbidity currents and salt deformation are linked through the seafloor topography that generated as result of the system's evolution. The flow of the salt acts to produce the structurally controlled channelization that is not due to turbidity current self-forming channels. It is due to the salt-influenced structure acting laterally to confine the turbidity current, and that affects the depositional pattern and transport ability of the sediments by the current. Most experiments and models emphasizing structural deformation tied to sediment-induced substrate flow are over constrained. Here, we allow turbidity currents, ensuing deposits and the structural deformation associated with substrate flow to co-evolve. Two experiments with different original substrate thickness are perturbed by similar initial pressure gradient force resulting from turbidity current sedimentation. Turbidity currents of the same intrinsic property are released from an updip point source onto an initially horizontal surface of mobile substrate. The difference in initial conditions results in bifurcation phenomena. In the thick salt case, original salt is sufficiently thick to relax turbidite loading to isostatic state, forming a minibasin. Sediment trapping efficiency increases as the relief of the minibasin is enhanced by subsequent turbidite loading. The steepening of minibasin margins over time led to gravitational collapse of turbidites that remobilized turbidite loading. The continuous subsidence of the minibasin into the thick salt induces salt breaching. Coalescence of salt sheets fully encased the minibasin and formed a structurally controlled channel, bypassing sediments to the downdip region where another minibasin formed. In the thin salt case, thinner salt is perturbed to a non-isostatic state during the initial loading, forming a tapered topography with radial set of normal faults. The subsequent salt deformation is strongly associated with the turbidite thickness gradient and spatial change in that gradient (thickness curvature) from the initial loading. The growth of a reactive diapir and continuous segmentation of turbidite over thin salt led to the development of a network of structurally controlled submarine channels that affects the sedimentation pattern, fueling the development of the structures that bypass more sediments to the downdip regions. In both cases, the emerging topography is not fully coupled with the turbidity currents until relief approaches half of the current basal layer thickness. Confinement width, relief, downdip position, and the sediment-salt budgets associated with that position have the first order control on localization of morphodynamics, populating fields of salt-influenced structures. Our experimental approach creates structures with geologically realistic geometries. This suggests that the model results should help unravel criticality that prescribes the emergence of a wide range of the salt-influenced structures.

Keywords: Turbidity currents, salt tectonics, complex systems, bifurcation phenomena, morphodynamics, geodynamics

LCPHD

Seismic data augmentation for automatic faults picking using deep learning

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We propose a method to generate seismic images with corresponding fault labels for augmenting training data in automatic faults detection. Our method is based on two generative adversarial networks: one network for creating faults system and the other for generating 2D seismic images with faults as a condition. Our method can capture the characteristics of field seismic data during inference in order to generate samples that have properties of both field seismic data and synthetic training data. It is helpful when we use these newly generated data for training a convolutional neural network for faults picking, as the training data will resemble the field test data. As we use faults system as a condition when generating seismic data, we have correct labels for the generated data. We test the proposed approach on a 3D field dataset from Gulf of Mexico. We use different areas in the field dataset as an input to generate new training data for corresponding faults picking models. The results show that our method helps to improve the faults picking models in the targeted areas.

Keywords: Machine learning, Seismic interpretation, Faults picking, Data augmentation

LCPHD

Englacial stratigraphy over a newly discovered widespread subglacial hydrology system in Princess Elizabeth Land, East Antarctica

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A widespread subglacial hydrology system was recently identified by airborne geophysical survey in Princess Elizabeth Land (PEL), East Antarctica. This subglacial hydrology system is composed of a large subglacial lake (hereby referred as Lake Snow Eagle, LSE) that is over 40 kilometers long and 10 kilometers wide, and multiple smaller subglacial water bodies around LSE. In this presentation, we propose to show geophysical evidence supporting the existence of this widespread subglacial hydrology system, and the englacial stratigraphy in this area mapped by airborne ice penetrating radar. The englacial stratigraphy could provide insight on the basal melting and refreezing patterns of this subglacial hydrology system, as well as the change of ice flow configuration induced by it. From the englacial stratigraphy, we also propose to discuss the spatial variation of the englacial submergence rate, and the impact on the ice sheet dynamics linked to the subglacial hydrology system.

Keywords: Cryosphere, Antarctic Ice Sheet, Ice-penetrating Radar

LCPHD

3D high resolution sequence stratigraphy of a forced regressive aeolian to shoreface carbonate grainstone system, the Marine Isotope Stage 5a succession across the Western Atlantic, Bahamas region

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Quaternary interglacial deposits on shallow carbonate island platforms preserve some of the highest resolution records for sea-level history. Relatively tectonically stable carbonate systems, such as the Bahamas region, are modulated by sea level, and are prime localities for using coastal archives to improve the timing and amplitude of sea level as well as the relationship with Glacial Isostatic Adjustment (GIA). This study aims to map out the forced regressive aeolian to shoreface carbonate grainstone system of the Marine Isotope Stage 5a (MIS 5a) succession following the Last Interglacial Highstand (LIG). Detailed field mapping of MIS 5a facies across the Western Atlantic, absolute U-Th dating of in-situ coral-rich marine facies from the Florida Key Reef Tract, and application of modern remote sensing data (LiDAR, TanDEM, UAV-based DEMs) will provide an opportunity for major advances beyond using traditional field mapping techniques alone. We propose using this multi-faceted approach to address: 1) sedimentological characterization and refinement of the post-LIG MIS 5a evolutionary model, 2) investigation of climatic variability for the MIS 5a highstand, and 3) a regional synthesis for MIS 5a sea level trends across the Western Atlantic. Data collected from Florida, Abaco, Eleuthera, San Salvador, and the Turks and Caicos, suggests a latitudinal variation on Whale Point skeletal sediment composition likely to be driven by climate and ocean temperature despite relatively homogenous representations of LIG deposits across a similar geographic area. Results from this study will contribute to a larger effort by the Kerans research group, in collaboration with Exxon, to build a late Quaternary island evolution framework for the Bahamas. These contributions will help build a more complete understanding of the potential origins of stratigraphic and reservoir heterogeneity, with a particular focus on icehouse reservoir systems.

Keywords: Carbonates, Sedimentology, Remote-Sensing, Field-Mapping, Stratigraphy

CCG

LCPHD

Non-stationarity of ENSO in CESM since the LGM: Implications for coral proxies

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El Niño-Southern Oscillation (ENSO) events are marked by changes in sea surface conditions across the tropical Pacific. Here we evaluate ENSO since the Last Glacial Maximum (LGM) in time slice experiments conducted with the Community Earth System Model version 1.2 (CESM). CESM shows the largest reductions in ENSO variance 18-12 thousand years ago (ka), when the background zonal sea surface temperature (SST) gradient is largest. We further show that changes in ENSO variance correlate with subtle changes in the spatial pattern of ENSO. Model results are forward-modeled to pseudocoral to compare with paleo-coral records; however, few coral records exist before 7 ka to compare to older model output. We conclude that increasing spatial coral data coverage across all time intervals, from past to present, helps to constrain changes in ENSO.

Keywords: El Niño, ENSO, CESM, LGM, Holocene, Coral

CCG
LCPHD

Advancing the Local Climate Zones classification method in Austin for Understanding Urban Extreme Weather

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The Local Climate Zones (LCZs) classification scheme developed by Stewart and Oke in 2012 has been widely used in urban heat island observational and modeling studies. As the capital of Texas, Austin is one of the fastest growing major cities in the United States, with 34% population growth since 2010. This study investigated the performance of using different machine learning classifiers (convolution neural networks (CNNs), K-Nearest Neighbor (KNN), Random Forest (RF), Gaussian Naïve Bayes (GNB), and Artificial Neural Network (NN)) and input features (Landsat 8, building height, and imperviousness) to generate a LCZs map for Austin. Recent studies have shown that CNNs can significantly improve classification accuracy. However, it requires multi-pixel input, which will lower the spatial resolution of the product. Therefore, this study also investigated other classifiers which ingest single-pixel input. In this study, 70% of the labelled pixels were used as training and 30% were used as verification. The results show that CNN performs the best (F1-score: 0.828) among all mentioned classifiers, and RF performs the best among the single-pixel classifiers (F1-score: 0.726). Recent studies show that urban-type LCZs can be improved by including a regional building height dataset. This study showed that both building height and imperviousness dataset could enhance the accuracy of urban-type LCZs in CNN and RF classifier. Particularly, the building height dataset improves the accuracy of the high- and mid-rise LCZs, and the Global Man-made Impervious Surface (GMIS) improve the low-rise LCZs in the RF. The LCZs map is being used in meso-scale modeling study to improve understanding about urban meteorology under extreme conditions such as heatwaves and hurricanes.

Keywords: Local Climate Zone, Machine Learning, Urban

CCG

LCPHD

Taxonomic assessment of Early Jurassic macrofauna from the High Atlas Mountains of Morocco*Sinha Sinjini**Sinha, S., Department of Geological Sciences, Jackson School of Geosciences, The University of Texas at Austin, USA**Martindale, R., Department of Geological Sciences, Jackson School of Geosciences, The University of Texas at Austin, USA**Little, C., School of Earth and Environment, University of Leeds, United Kingdom**Stone, T., Department of Geological Sciences, Jackson School of Geosciences, The University of Texas at Austin, USA**Fonville, T., Department of Geological Sciences, Jackson School of Geosciences, The University of Texas at Austin, USA**Bodin, S., Department of Geoscience, Aarhus University, Aarhus, Denmark**Kabiri, L., Department of Geological Sciences, University Moulay Ismail, Errachidia, Morocco*

Marine communities in the Early Jurassic experienced varying degrees of biotic crises at the Pliensbachian/Toarcian boundary, ~183.5 million years ago, and during the Toarcian Oceanic Anoxic Event (TOAE), ~183 million years ago. Though not as severe as the biggest mass extinction events (e.g., the endPermian), Early Jurassic extinctions are thought to be caused by similar environmental stresses such as ocean warming, anoxia, and acidification, resulting from a Large Igneous Province eruption. Nevertheless, the exact causes of the extinctions are debated, most likely due to limited data availability from shallow water carbonate strata from lower latitudes. Previous work from Lower Jurassic sections in the High Atlas of Morocco suggests that biotic changes in communities living in carbonate shelves in Morocco were coincident with a two-phased carbonate factory collapse; however, the carbonate communities seemed to recover relatively quickly. Therefore, we will study the faunal composition of level-bottom communities before the extinctions and during the recoveries to assess how these communities responded to the environmental changes. To investigate the cause and significance of the change in community dynamics across these two events, we quantify occurrences and abundances of different fauna from shallow marine carbonate strata in the Central High Atlas Mountains of Morocco. This study includes a preliminary assessment of the macrofauna sampled from different late Pliensbachian and early Toarcian localities. The different macrofaunal groups studied herein include species of ammonites, bivalves, brachiopods, echinoids, and gastropods. Quantification of fossil invertebrate communities will allow analyses of long-term trends in community structure and provide data to assess the plausibility of local kill mechanisms. For example, if heat stress or ocean acidification are significant factors, we would see a significant loss of heat or lowered pH sensitive taxa respectively. Quantification will also determine how the marine communities changed in response to environmental stressors at each event and what environmental or taxonomic factors dictated survival versus extinction. Broadly, community survival through smaller extinctions provide important data for survival strategies of organisms, which can be used for modern marine conservation.

Keywords: Toarcian Oceanic Anoxic Event, Large Igneous Province, level-bottom communities, ocean acidification, marine conservation

CCG
LCPHD

Assessing Moroccan reef architecture and communities to define the role of extinctions in Early Jurassic reef evolution

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The Early Jurassic was a tumultuous time for reef ecosystems, with multi-phased extinctions at the Pliensbachian/Toarcian (Pl/To) boundary event and the Toarcian Oceanic Anoxic event (T-OAE). Excellent Lower Jurassic reef deposits occur in the Central High Atlas region of Morocco, where changes in reef communities can be assessed in the context of the Pl/To and T-OAE. Analyses of the changes in reef architecture and fauna provide insight into how the environmental stresses associated with each extinction event (i.e., ocean acidification and ocean warming) impacted these ecosystems. Although these events resulted in catastrophic extinctions for the main reef builders (corals and lithiotid bivalves), reef recovery occurred quickly; therefore, an assessment of reef communities in the wake of each event, which documents how new faunas filled critical reef niches, may provide insight into the cause of the accelerated recovery.

The faunal and structural differences between early Pliensbachian, late Pliensbachian, earliest Toarcian, and post-T-OAE reefs in this region are not currently well known, so we are describing reefs at each interval. Specifically, we are assessing their structural and compositional characteristics (i.e., framework and interstitial component percentage and composition, similarity profiles) and comparing them to one another using ecological metrics (i.e., abundance, diversity, evenness, and richness). Analyses of these deposits will allow us to understand what environmental conditions led to the Early Jurassic extinctions in reef ecosystems, how the structure of reefs changed following these events, why certain taxa survived while others did not, and what conditions led to reef recovery.

Visualization can be a powerful teaching tool. While in Morocco, we had the opportunity to construct virtual field sites representative of several locations with two goals in mind. The first is to introduce lab members and new collaborators to field sites, and secondly, to create a teaching tool for geologic concepts and field techniques for classes for both graduate and undergraduate students. The exceptional exposure of thick sedimentary rock layers in Morocco is advantageous for the creation of virtual field sites, as it provides a three-dimensional view of geological concepts such as structure and stratigraphy, and provides a real-world location to observe field techniques. These will be guided and goal-oriented virtual experiences that allow students to discover the features of each site by displaying annotated outcrops, links to relevant research papers, and descriptive videos. Virtual experiences, such as these, convey the importance and educational value of these sites to a larger audience of geoscientists around the globe.

Keywords: Mass Extinction, Paleontology, Jurassic, Reef, Climate, Virtual Reality, Virtual Field Trip

CCG

LCPHD

Changes in Extreme Rainfall Events under Global Warming: A Case Study for Texas*Sabiha Tabassum**Tabassum, S., Jackson School of Geosciences, The University of Texas at Austin, Austin, TX**Wu, W., Jackson School of Geosciences, The University of Texas at Austin, Austin, TX**Yang, Z., Jackson School of Geosciences, The University of Texas at Austin, Austin, TX**Shukla, A., Cockrell School of Engineering, The University of Texas at Austin, Austin, TX**Kutanoglu, E., Cockrell School of Engineering, The University of Texas at Austin, Austin, TX**Hasenbein, J., Cockrell School of Engineering, The University of Texas at Austin, Austin, TX**King, C., Energy Institute, The University of Texas at Austin, Austin, TX**Santoso, S., Cockrell School of Engineering, The University of Texas at Austin, Austin, TX*

Changes in the frequency and severity of extreme weather events are going to be one of the most impactful consequences of global warming. As the atmosphere warms up, the amount of water vapor available for rainfall increases. Therefore, it is expected that in the future, severe weather events will be characterized by stronger rainfall rates. Consequently, this will increase the risk of flooding. Given the societal and economic impacts of a flooding event, we must have a better understanding of how it may be changing in the future. This study investigates the impact of climate change on extreme rainfall events over Texas. Texas is selected as the testbed because it is natural disaster-prone as well as comprises big metropolitan cities with high populations. Climate model's ability to simulate observed rainfall characteristics over Texas is assessed. Simulations from phase 6 of the Coupled Model Intercomparison Project (CMIP6) reveal that the models can simulate the mean observed behavior but underestimate the magnitude of extreme rainfall events due to their coarse resolution. According to the SSP5-5.5 simulations, the multi-model median change in annual maximum 5-day rainfall (Rx5day) follows the C-C scale (7%/K) closely in the near term (2021-2050) but is much lower than C-C scale in the long term (2071-2100) when compared to the historical period (1985-2014). This indicates towards inhibition of rainfall development by high surface temperature over Texas. Robustness of this feature needs to be assessed.

Keywords: Climate change, Global warming, Extreme precipitation

CCG
LCPHD

Modeling riverine nitrogen transport through the coupled Noah-MP-CN Land Surface Model and the RAPID River Routing Model

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Excessive nitrogen is the leading nutrient causing the continued spread of hypoxia with the major controls of precipitation. Urban and agricultural runoff can primarily increase nitrogen loading into watersheds, even though it remains unclear how changes in precipitation and anthropogenic nitrogen fluxes might affect loading into watersheds and, thereby, export to oceans. The community Noah land surface model with multi-parameterization (Noah-MP) was recently extended to simulate the terrestrial nitrogen cycle by embedding soil nitrogen dynamics from the Soil and Water Assessment Tool and plant nitrogen uptake processes from the Fixation and Uptake of Nitrogen (hereafter, Noah-MP-CN). Noah-MP-CN demonstrated its capability to model key N flux, including nitrate leaching in U.S. and China. To have a more comprehensive nitrogen transport for advanced water quality predictions, we developed a river nitrogen transport model by coupling Noah-MP-CN and the Routing Application for Parallel computation of Discharge (RAPID), a vector-based river routing model (hereafter, Noah-MP-CN-RAPID). RAPID is efficient in representing the horizontal water movement in large river networks containing thousands of reaches. RAPID demonstrated the improved ability to transfer runoff to streamflow with the coupled mode of Noah-MP. We assessed the model efficacy in simulating river nitrogen fluxes at the San Antonio and Guadalupe River Basins in Texas from 1981 to 2018 against the Texas Water Development Board (TWDB) and the United States Geological Survey (USGS) gauge observations. This study showed Noah-MP-CN-RAPID was capable of reproducing the observed nitrogen concentrations in these two river basins. In summary, Noah-MP-CN-RAPID shows the promise as a useful model for advanced environmental predictions. This study suggests that reducing human-induced nitrogen loading into upland watersheds is critical to improving water quality.

Keywords: nitrogen dynamics, Noah-MP, land surface model, nitrate leaching

CCG
LCPHD

Drought Identification in NLDAS Data using Machine Learning Methods

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Though machine learning (ML) methods have been around for decades, they have only more recently been adopted in the geosciences. The availability of existing long data records combined with the capability of ML algorithms to learn highly non-linear relationships between data sources means there is even more potential for the replacement or augmentation of existing scientific analyses with ML methods. Here, I give an example of how I used a convolutional neural network (CNN) for the task of pixelwise classification of the North American Land Data Assimilation System (NLDAS) Total Water Storage data into their corresponding drought levels based on the Palmer Drought Severity Index (PDSI). Promising results indicate there is much to be explored in the application of ML to drought identification and monitoring.

Keywords: Drought, Machine Learning

EG

LCPHD

Seismic Expressions of lower Wolfcampian Tannehill Channel System in King County on the Eastern Shelf of the Midland Basin, Texas

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This study reconstructs one of the significant oil-producing fluvial channel-fill and meander belt facies on the Eastern Shelf - Midland Basin, TX. During the regressive episode of lower Wolfcampian (between Saddle Creek to Lower Stockwether), the Eastern Shelf experienced a high amplitude glacio-eustatic sea-level fall that aerially exposed the shelf. Additionally, large volumes of sediments were released by the influence of the rejuvenation of the Ouachita fold belt. The amount of sediment influx kept up with the rate of relative sealevel fall, which resulted in westward extension of lower Wolfcampian Tannehill channels, incising underlying Saddle Creek transgressive limestones.

We undertook seismic attribute approach to gain a better understanding of the Tannehill unit that preserved the fluvial channels. We performed spectral decomposition and seismic attribute analysis on the 3D seismic dataset. As a result of this study, six channels within the Tannehill unit have been identified. Four of these channels have been mapped over a distance of ~ 40 km are located in the southern part of the seismic area, trending east-west direction. Three channel deposits are between 90 to 150 m wide with ~ 1.1 sinuosities, and one formed a 915 m channel belt (at the widest location) with ~ 1.85 sinuosity. The meander amplitude of the widest channel belt reaches up to 1.8 km. Another set of channels, about 90 - 150 m wide with ~ 1.1 sinuosity, are observed in the northern part of the study area, trending northwest to southeast.

The next steps of the project are to understand the influence of the substrate lithology on the channel geometries and to populate the channel features with ground truth porosity and permeability properties, which will be collected from the outcrops.

Keywords: 3D seismic, seismic interpretation, seismic attributes, spectral decomposition, fluvial, channel, meander, sinuosity, Eastern Shelf, Midland, Permian, Texas

EG
LCPHD

Boundary conditions for acoustic and elastic wave propagation using deep learning

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We propose a deep learning framework to simulate the effect of boundary conditions for wave propagation in anisotropic media. To overcome the challenges associated with stability of conventional implementation of boundary conditions for strongly anisotropic media, we propose an efficient algorithm using deep neural networks. We train the network using a few shot locations and time-slices enabling the network to learn how to remove boundary reflections and simulate wave propagation for unbounded media. The benefit of this approach is its simple implementation and significant reduction of reflections at the boundaries, especially, in the case of tilted transverse isotropic media. We validate the proposed approach by comparing wave propagation at the boundaries using the proposed algorithm with the output obtained using the unbounded media simulated by padding the model. Tests on different models with acoustic and elastic wave propagation verify the effectiveness of the proposed approach.

Keywords: boundary conditions, Machine learning, wave-propagation

EG
LCPHD

Pore Pressure Prediction in Unloaded Basins with Case Study in Delaware Basin

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I present a new workflow to predict pore pressure from velocities in unconventional basins that have been unloaded. Unlike previous empirical-based approaches that neglect to account for the physical impact of unloading on mudrocks, my method incorporates soil behavior using an elastoplastic unloading model coupled with a pore pressure buildup coefficient to solve for preconsolidation stress. I demonstrate my method in the highly unloaded eastern portion of the Delaware Basin. I use well log and measured pore pressure data to establish a relationship between velocity and vertical effective stress in a well with a known erosional value. I use this relationship to predict the regional variations in erosion and vertical effective stress from velocities in five wells spanning basin. I calculate pore pressure as the vertical total stress less the vertical effective stress. I demonstrate the predictive capability of this approach by comparing the results against measured pore pressures that I interpret from drill-stem tests (DSTs).

Keywords: Pore pressure prediction, unconventional basins, Permian basin

EG

LCPHD

Simultaneous natural gas production and CO₂ storage in gas hydrates: unique ‘slimtube’ flow experiments*Zachary Murphy**Murphy, Z., Institute for Geophysics, The University of Texas at Austin, Austin, TX**Flemings, P., Institute for Geophysics, The University of Texas at Austin, Austin, TX**DiCarlo, D., Hildebrand Department of Petroleum and Geosystems Engineering, The University of Texas at Austin, Austin, TX**You, K., Institute for Geophysics, The University of Texas at Austin, Austin, TX*

Perhaps the greatest challenge we face on Earth is how to meet the growing demand for energy while avoiding the environmental and societal impacts of a rapidly warming planet. We propose a nearcarbon-neutral strategy to meet the challenge of limiting the negative impacts of climate disruption while supplying enough energy to meet the growing demand. Methane trapped as gas hydrate is one of the most abundant unconventional energy sources on earth. However, current production technologies are not economic because during production, the reservoir cools dramatically, produces an abundance of water, and becomes mechanically unstable. We propose to simultaneously produce CH₄ and store CO₂ within these hydrate reservoirs by pumping in a CO₂+N₂ gas mixture in one well and pumping CH₄ out another well. During this process, the injected N₂ dissociates CH₄ hydrate and pushes CH₄ downstream toward the production well. Directly behind this disassociation front, CO₂ hydrate forms, solidifying the liberated water, providing heat for further production, and maintaining the geomechanical stability of the reservoir. We test this methodology by forming methane hydrates in a ‘slimtube’ vessel. We then inject a CO₂+N₂ gas mixture and observe the gas effluent. Using gas chromatography, we can clearly see the predicted dissociation and formation fronts moving through the sample. These experiments show that this method for methane production and CO₂ storage is feasible for large scale testing.

Keywords: methane hydrates, carbon storage, fluid flow

EG

LCPHD

Benthic oxygenation history during deposition of the Upper Cretaceous Austin Chalk Group of south Texas: An integrated sedimentologic, ichnologic, and geochemical approach*Yu-Chen Zheng**Zheng, C., Department of Geological Sciences, The University of Texas at Austin, Austin, TX**Loucks, R., Bureau of Economic Geology, The University of Texas at Austin, Austin, TX**Kerans, C., Department of Geological Sciences, The University of Texas at Austin, Austin, TX**Buatois, L., Department of Geological Sciences, University of Saskatchewan, Canada**Mángano, M., Department of Geological Sciences, University of Saskatchewan, Canada**Ko, T., Bureau of Economic Geology, The University of Texas at Austin, Austin, TX*

Oxygen concentration in the ocean has been a subject of intensive research because of the relationship between level of oxygenation and preservation of organic material and potentially the formation of source rocks. Several ephemeral but distinct oceanic anoxic events (OAEs) occurred within the Cretaceous and contributed to source-rock development in the Tethyan Ocean. Recent studies defined basic lithofacies and identified organic-rich intervals in the subsurface Austin Chalk Group and ascribed them to be related to oxygen-depleted conditions in the oceans, calling attention to investigate the potential of presence of “OAE III” in South Texas. Classic zonations of oxygen deficiency in the ocean are defined on the basis of biofacies; trace fossil records are essential for interpreting interstitial water oxygen levels in the sediments. However, detailed infaunal organism activities responding to benthic oxygenation in South Texas during the Austin Chalk Group deposition have not been exemplified. This study aims to reconstruct South Texas's benthic oxygenation history during Austin Chalk deposition by applying detailed ichnologic analysis and integrating sedimentological and geochemical (XRF, XRD) data.

The continuous core recovery of Gise #1 Core from Dimmit County, South Texas, makes ichnologic analysis an ideal approach to enhance sedimentological analyses of the Austin Chalk interval. While the ichnofacies (distal *Cruziana* transitional to *Zoophycos* Ichnofacies) and sedimentological analyses suggest a shelfal environment in the Austin Chalk Group, ichnofabric analysis yields insights into the hydrodynamics in the environment. Four oxygen-related ichnocoenoses illustrate interstitial oxygen levels from anaerobic to dysaerobic to fully oxygenated conditions. This interstitial oxygen-level trend implies a benthic oxygenation recovery in the ocean. Supplementary geochemical data concur with this trend and further identify anoxic/euxinic conditions in the anaerobic facies: Mn serves as an oxygenation proxy and shows an increase in value along with this trend. The decrease of Mn value in the upper part of Austin Chalk is derived from the dilution effect, as shown by the increased terrigenous input. Enriched redox-sensitive trace elements, V and Mo in the Two Fingers zones and lowermost part of the Austin Chalk, indicating periods of anoxic conditions in the bottom water, perhaps related to paleoproductivity blooms, as shown by the elevated nutrient proxies, Ni, Cu, and Zn. The reconstructed benthic oxygenation history during Austin Chalk Group provides insights into variable, evolving paleoclimatic and paleoceanographic conditions of the greenhouse Late Cretaceous and is directly applicable to improve global source-rock exploration concepts. The results are expected to be analogous to coequal settings in the Gulf of Mexico during this time period.

Keywords: Benthic oxygenation, ocean anoxic event, Upper Cretaceous ocean evolution

PS

LCPHD

Physics guided deep autoencoder to overcome the need for a starting model in full waveform inversion*Arnab Dhara**Dhara, A., Jackson School of Geosciences, The University of Texas at Austin, Austin, TX*

Full Waveform Inversion (FWI) is the most popular technique to obtain high resolution estimates of earth model parameters using all information present in seismic data and thus can provide important information about the sub-surface. The FWI algorithm is formulated as a data-fitting minimization problem that updates an initial velocity model using the gradient of the misfit until we obtain an acceptable match between the real and synthetic data under a tolerance level based on the noise in the data. The inversion is computationally expensive and can converge to a local minimum if the starting model used is not close enough to an optimal model.

Here, we propose an alternative approach using a combination of machine learning and the physics of the forward model. Unlike a conventional supervised machine learning, we do not require known answers to train our network. The shot gathers are input to a neural network-based auto encoder whose output is used as the velocity model that is used to compute synthetic. The synthetic data are compared against observed input data and the misfit is estimated. The gradient of the misfit with respect to the velocity model parameters is calculated using the adjoint state method. The adjoint state gradient is then used to update the network weights using the automatic differentiation technique. Once the misfit term converges, the neural network can generate velocity models consistent with the observed data. We observe that the neural network can capture spatial correlations at different scales and thus can introduce regularization in our inverse problem. Experiments with the model and Phase 1 SEAM salt model suggest that the proposed method can overcome local minima, requires no starting model, and produce robust results in presence of noise and complex salt body structures.

Keywords: Deep learning, full waveform inversion

EG

LCPHD

Correcting Anisotropic Seismic Data with Deep Learning for Full Waveform Inversion*Dimitri Voytan**Voytan, D., Institute for Geophysics, Jackson School of Geosciences, The University of Texas at Austin**Sen, M., Institute for Geophysics, Jackson School of Geosciences, The University of Texas at Austin*

Full waveform inversion is a data fitting method used to infer subsurface physical properties. Many choices of the parameterization of the subsurface are available and each parameterization presents a tradeoff in computational speed, accuracy, and resolvability from surface seismic data. We specifically consider the deficiency of the acoustic parameterization (P-wave velocity) in media with significant anisotropy. In this context, anisotropic propagation effects are primarily resolved as nonexistent heterogeneities. To circumvent this problem, we propose a deep learning based method to correct anisotropic data to equivalent isotropic data. In a synthetic example, we show that a deep convolutional network can learn a mapping from anisotropic shot gathers to acoustic equivalents. Furthermore, we show that this mapping meaningfully improves acoustic full waveform inversion of anisotropic data. Because the acoustic approximation is still routinely used in industrial applications, our proposed workflow is relevant to current challenges in oil and gas exploration.

Keywords: Seismology, Full Waveform Inversion, Anisotropy

PS

LCPHD

Full waveform inversion using adaptive quasi-Newton method*Ricardo Silva Nunes de Braganca**Braganca, R., Institute for Geophysics, Jackson School of Geosciences, The University of Texas at Austin
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Full waveform inversion (FWI) uses all information in seismic data to estimate high-resolution earth model parameters. It is an ill-posed nonlinear inverse problem that is very computationally demanding and is prone to sub-optimal convergence in local minima. In this work, we address these issues using a recently developed machine learning optimization technique called Adaptive Quasi-Newton optimization (ADAQN). Like other second-order algorithms, this technique incorporates curvature information in the inversion but without the need to store or compute the expensive Hessian matrix, leading to a computational cost similar to that of first-order methods. The algorithm can deal with the erratic gradients commonly occurring in mini-batches, allowing the inversion to be performed in the stochastic regime. Thus, it is more robust to local minimum issues. We tested the algorithm on the SEAM 2D model with excellent results. We also used a stochastic approach by randomly shuffling the sources and thereby improving the convergence further.

Keywords: Full Waveform Inversion, Optimization, FWI, Inversion, Machine Learning, AdaQN

EG

LCPHD

Constraining the paleoenvironment of the Darwin outcrop in Gale crater from facies and stratigraphic mapping*Michelle Tebolt**Tebolt, M., Jackson School of Geosciences, The University of Texas at Austin, Austin, TX**Goudge, T., Jackson School of Geosciences, The University of Texas at Austin, Austin, TX**Stack, K., Jet Propulsion Laboratory, California Institute of Technology**Fedo, C., Dept. of Earth & Planetary Sciences, UT Knoxville, Knoxville, TN**Gwizd, S., Dept. of Earth & Planetary Sciences, UT Knoxville, Knoxville, TN*

The Bradbury Rise Traverse includes data collected from sols 0-750 of the Mars Science Laboratory (MSL), *Curiosity*, mission within Gale crater. Although the stratigraphic section of the Bradbury Rise has already been analyzed and interpreted as a prograding braided river delta when data was first collected, many specific sites have yet to be evaluated in great detail. This work aims to study the stratigraphy of one area along the Bradbury Rise traverse, the Darwin outcrop, in order to interpret the paleoenvironment. The rocks in this location can be used to address the broad topic of habitability on a local level with the overall goal of providing more context and information about early martian climate and atmospheric conditions. Images from the Navigation Camera (Navcam), the Mast Camera (Mastcam), and the Mars Hand Lens Imager (MAHLI) were downloaded from the MSL Analyst's Notebook on NASA's Planetary Data System. The Mastcam images were examined for any sedimentary outcrop and analyzed further using ENVI. Preliminary observations made of each image include categorical grain size, bedding type, and any other obvious sedimentary structures. A preliminary facies map has been created for sols 392-395 using Mastcam images in context with Navcam images. Three facies have been identified and characterized including conglomerate, gravelly sandstone, and dark float.

The rocks in the gravelly sandstone facies appear to have horizontal-to-wavy surfaces embedded within layers. An early, working interpretation is that these could be diagenetic features, or possibly primary sedimentary structures (e.g., bedform cross-strata) that would aid with paleoenvironmental reconstruction. Next steps involve completing the analysis of all Mastcam images from sols 392-401 and further developing the facies map of the outcrop. The units will then be examined at a smaller scale using MAHLI images to perform a clast survey, of particular relevance to the conglomerate facies. This data will inform us on the possible modes of sediment transport and deposition of the grains based on, for example, measurements of roundness and grain size. As a final step to get a complete picture of the paleoenvironment, a 3D facies map will be created of the region. This will then be used to make quantitative measurements of sedimentary structures, to constrain possible flow directions and depths.

Keywords: Mars, Remote sensing, Sedimentology

PS

LCPHD

Impact driven groundwater divide migration on early Mars

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We investigate the compartmentalization of the hypothesized deep aquifer beneath Mars' southern highlands on Noachian Mars. Specifically, we investigate a scenario where the northern lowlands, as well as the Hellas and Argyre basins, contained coeval large water bodies and that groundwater recharge was spatially uniform. The different shorelines proposed for these water bodies create regional hydraulic gradients that interact with the recharge to determine the compartmentalization of the groundwater system and hence the potential communication between these proposed water bodies. We conduct models both with and without Hellas and Argyre basins being emplaced to investigate the response of the groundwater system to their formation.

Keywords: Mars, Hydrology, Impacts, groundwater

SETP
LCPHD

What do microlites tell us about obsidian pyroclasts?

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One model for formation of obsidian pyroclasts suggests that they form through sintering of ash particles on volcanic conduit walls, which are subsequently torn out and entrained in the gas-particle dispersion out of the erupting vent. Here, we investigate microlite abundances and textures in obsidian pyroclasts in order to determine the time required to produce adequate numbers of microlites, and hence the pyroclasts themselves. We measured microlite number densities (MNDs) and microlite and vesicle orientations in obsidian pyroclasts in tephra deposits from the ~1340 A.D. North Mono eruption. MNDs increase with decreasing dissolved H₂O concentrations. Also, microlite spatial orientations become less aligned and differ more from vesicle orientations with decreasing dissolved H₂O concentrations. MNDs increase from the second layer (P2) through the final layer (P10). To investigate timescales required to replicate MNDs in the North Mono obsidian, we performed time, temperature and pressure-controlled experiments with rhyolitic glass from the same eruption. MNDs in our experiments initially increase with decreasing pressure (50-35 MPa), then decrease as pressure decreases further (35-10 MPa). MNDs in obsidian from layers P2-P10 were replicated in ~7 hours or less. Based on these observations we propose a model where during the initial phase of the North Mono eruption most obsidian formed close to the magmatic fragmentation depth, equilibrated for short time periods (< 7 hours) and were then erupted out of the volcanic vent. These obsidian clasts have lower MNDs than subsequent phases, and microlites are generally well aligned with each other and with vesicles, reflecting their shorter residence times in the conduit, higher dissolved H₂O contents, and lower viscosities. During later phases of the North Mono eruption obsidian formed at various depths in the conduit, equilibrating for longer periods of time (≤ ~7 hours) before being erupted out of the vent or sintering together with other clasts and equilibrating at shallower depths before being erupted. These obsidian clasts have higher MNDs than earlier phases of the eruption, and microlites are generally not well aligned with each other or with vesicles, reflecting their variable residence times in the volcanic vent, lower dissolved H₂O contents, and higher viscosities.

Keywords: microlite, vesicle, obsidian, petrology, Mono Craters

SETP
LCPHD

The structural and morphological evolution of transpressive systems: insights from analog modeling

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The relationships between deformation and erosion in transpressive systems are still poorly understood. Here, we present a new set of analog models to investigate how the tectonic and surface processes present at largescale transpressive plate boundaries interact to shape topography. The experimental setup comprised a 2 x 1 x 0.5 m³ plexiglass box fit with a plexiglass board cut to 20° obliquity. A motor pulled a mylar sheet beneath the board to generate a velocity discontinuity at the interface. We loaded a ~5 cm thick layer of a granular material onto the board and sheet composed of 40 wt. % silica powder, 40 wt. % glass microbeads, and 20 wt. % PVC powder (cf. CMII in Reitano et al., 2020, doi: 10.5194/esurf-8-973-2020). This setup allows deformation to nucleate at the velocity discontinuity and naturally form a transpressional wedge. The model was monitored with digital cameras and a laser scanner to conduct particle image velocimetry and digital elevation model analysis, respectively. To explore surface processes associated with mass transport and erosion, we used a sprinkler system that casts a uniform mist across the model surface. We allowed ~1 cm of relief (equivalent to ~10 cm of convergence) to form before misting began to ensure the formation of realistic drainage networks. Before misting, experiments evolved in 3 stages: 1) distributed strain, 2) strike-slip faulting along synthetic structures, and 3) uplift and formation of a wedge along bivergent thrust structures. After misting, strike-slip deformation was still fully partitioned to synthetic structures and thrust sheets propagated in the prowedge direction. As the experiment continued, sub-longitudinal drainage systems formed with their orientation controlled by synthetic structures. Strike-slip displacement along these structures interrupted transverse streams, which ultimately captured the sub longitudinal systems. On the retrowedge, a longitudinal basin formed along a coalesced extensional structure, which also was later captured by transverse channels. These and other interactions between fault structures and channel networks provide insight into erosion and mass transport in transpressional systems and the nature of the complex reorganization of stream networks in response to deformation.

Keywords: Tectonics, Climate-tectonic interactions, surface processes, strain partitioning, fault evolution, channel network evolution

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Late Cretaceous-Paleocene deformation in the Maria fold-and-thrust belt (SE California and westcentral Arizona, USA): New insights from titanite EBSD and in-situ U-Pb petrochronology

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Titanite U-Pb petrochronology is a powerful method to constrain the ascertain of deformation and the interplay with metamorphism and magmatism in many lithologies, ranging from calc-silicates to plutonic rocks. Importantly, titanite can grow or recrystallize sub-solidus and during ductile or even brittle fluidassisted deformation conditions and hence has the potential to constrain the timing of shear and fault zones. While most in-situ titanite petrochronology studies have focused on the relations between age and their geochemical and petrologic conditions, few studies have tried to directly link petrochronology to the deformation conditions of these rocks. In this study, we integrated titanite electron backscatter diffraction (EBSD) combined with in-situ U-Pb petrochronology within X:Z thin-sections to examine Mesozoic to Cenozoic ductile shear fabrics in the SW USA. We investigated an extensional top-NE greenschist to amphibolite facies shear zone developed within Jurassic granitoids in the Big Maria Mountains, SE California. This shear zone overprints Late Cretaceous (~100-70 Ma) contractional fabrics of the Maria fold-and-thrust belt associated with Mesozoic retro-arc contraction of western North America. In this shear zone, titanite cores preserve Jurassic magmatic ages, while the titanite grain tips yield Late Cretaceous (~75-70 Ma) ages that are consistent with ~75-58 Ma apatite U-Pb cooling ages ($T_c \sim 450^\circ\text{C}$) from the same rocks. Late Cretaceous titanite U-Pb ages spatially correlate with lattice misorientations of 1-12° detected with EBSD analyses, while ~170-160 Ma (magmatic) ages correspond to areas with <1-2° of misorientation. EBSD analyses of these titanite indicate spatial correlation between higher dislocation density and subgrains and younger U-Pb ages along the edges of titanite grains. Coupled with microstructural evidence for rapid grain boundary migration in quartz and subgrain rotation and bulging recrystallization in K-feldspar and plagioclase, these data point to titanite as a reliable recorder of plastic deformation in quartzofeldspathic rocks, but also illustrate the need for systematic integration of quantitative microstructure and petrochronology to provide more in-depth tectonic insights in regions with complex histories.

Keywords: microstructure, geochronology, high-temperature thermochronology, shear zone

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Syn-rift Sedimentary Provenance during Progressive Rifting along the Eastern North American Margin, U.S.A.

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Our understanding of progressive rifting along continental margins and the processes leading to lithospheric break-up has greatly improved over the past decades. These advances allow for reconstructions of the kinematic, temporal, and thermal evolution of rifted margins. However, limited progress has been made in the understanding of the topographic evolution in response to progressive rifting and break-up nor the sedimentary source-to-sink dynamics of magma-poor or -rich rifted margins. The Triassic/Jurassic syn-rift basins along the Eastern North American Margin (ENAM) span the diffuse rifting, initial necking, and hyperextension phases and record the syn-rift sedimentary provenance evolution and the interplay between crustal thinning and transition to magmatic break-up. These ENAM rift basins, stretching from Canada to Florida, record the early tectonostratigraphic and 3-D geometric evolution of continental rifting, including ~30 Myr of syn-rift deposition prior to Central Atlantic Magmatic Province (CAMP) magmatism and subsequent continental break-up. The non-marine lithofacies of the Newark Supergroup comprise the initial syn-rift strata of the individual basins along the ENAM. Carnian-Sinemurian deposits occur in a series of half grabens with predominately east-dipping basin bounding faults controlled by pre-existing Appalachian structural grain. Here we present extensive new detrital zircon (DZ) and detrital apatite (DA) U-Pb results from Carnian-Sinemurian syn-rift sedimentary rocks of the Newark and Culpeper basins and reconstruct sediment dispersal pathways during progressive rifting and magmatism (CAMP). Distinct DZ and DA provenance shifts are observed in the Newark and Culpeper basins. This indicates two major paleodrainage reconfigurations occurred during progressive rifting along the ENAM due to (1) Early Norian rift flank uplift and crustal necking and (2) regional and local uplift associated with CAMP at the Triassic/Jurassic boundary. This shows the ability to track the surface response of progressive rifting and onset of magmatic break-up with DZ and DA provenance tools. These results also demonstrate the power of DA U-Pb analyses in unraveling provenance shifts, missed in DZ data, due to the ability to recognize both high and medium-T tectonomagmatic events.

Keywords: Rifting, Provenance, ENAM

SETP
LCPHD

Transient plate and plate boundary evolution in spreading settings from 3-D mantle convection models with damage memory

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Analyzing the plate-tectonic cycles that arise from thermo-chemical mantle convection is essential to understanding the history of plate tectonics. Here, we focus on the dynamics of oceanic lithosphere. We present results from axisymmetric 2-D and 3-D Cartesian convection computations with damage rheologies, with particular focus on spreading systems. Those have been previously studied within the plate generation context since their transform fault component and the associated localization are often considered hallmarks of Earth's style of planetary heat transport. We use the open-source code *ASPECT* for our viscoplastic computations and combine a quasi-strain ("damage") dependent yield stress with temperature dependent healing. We compare free convection cases with two different viscosity laws and heating modes. By modifying the convection style between models, we can analyze transients and transitions between different heating and viscosity scenarios and resulting modifications in the surface "plate" configurations. We track how shear zones initiate, evolve, shut off, and eventually re-initiate due to inherited lithospheric weakness and strain localization. We find multiple styles of spreading and transform-like structures, from near-orthogonal shear zones to the inception of microplates and explore the role of damage vs. memory-free rheologies for plate and convection configurations. We also find interesting subducting slab dynamics resulting in multiple modes of subduction within a single model.

Keywords: mantle convection, geodynamics, tectonics, spreading ridges

SETP
LCPHD

Emergence of supervolcanism at Valles Caldera as recorded by changes in oxygen fugacity and crystal cargo

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Hydrous high-silica rhyolites at Valles caldera typically contain either fayalite (F-type) or biotite (B-type); two phases that are often stable at different oxygen fugacities (fO_2). Interestingly, F-type rhyolites only erupted immediately before and during caldera-forming eruptions. Fayalite crystallization may likewise be associated with a shift in magma storage conditions from system perturbations that induce supervolcanism. We investigated how storage conditions (temperature, pressure, fO_2) of F and B-type rhyolites differ through fO_2 -buffered phase equilibrium experiments. Powdered samples of representative F and B-type rhyolites were run at fO_2 conditions ranging from the manganosite-hausmannite (~nickel-nickel oxide +4 log units) to the quartz-fayalite-magnetite (QFM) buffer curves. Critically, both the F-type and B-type mineral assemblages were reproduced simply by varying fO_2 . The F-type mineral assemblage (quartz + sanidine + clinopyroxene + fayalite + Fe-Ti oxides) was only reproduced, with or without biotite, at QFM conditions. In contrast, the B-type assemblage (quartz + sanidine + biotite + Fe-Ti oxides \pm clinopyroxene \pm hornblende \pm plagioclase) was reproduced without plagioclase and hornblende at fO_2 ~NNO. Furthermore, storage pressures and temperatures show little difference between F and B-type rhyolites. Combining our experimental data with geothermometry and H₂O-CO₂ melt inclusion pressure estimates, both F and B-type storage is constrained between and 690-750°C and 50-200 MPa. Therefore, the only change in storage conditions between F and B-type rhyolites is a difference in fO_2 . The ephemeral nature of F-type rhyolite eruptions suggests that the normal state of the system is at higher fO_2 (~NNO) conditions. System reduction may be driven by the flux of reducing fluids from the well documented recharge event that mixed in dacitic enclaves with the rhyolite that erupted as the Tshirege tuff during caldera formation. Recharge intensity evidently waned following caldera collapse, as recorded by the absence of any F-type rhyolites in the postcaldera eruption record. Fayalite versus biotite may therefore indicate the nature of system rejuvenation, with fayalite appearing only during intense recharge that may lead to supervolcanism.

Keywords: redox, supervolcano, Valles Caldera, magma storage

SETP
LCPHD

Forward-Inverse Modeling of Earthquake Cycle Deformation

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Analysis of coseismic and postseismic surface displacements can help to constrain the Earth's structure and physics of deformation mechanisms occurring at depth. Here, we propose a new finite-element (FE) based computational framework to solve forward and inverse elastic deformation problems for earthquake faulting including adjoint approaches. Based on two advanced open-source computational libraries, FEniCS and hippylib for the forward and inverse problems, respectively, this framework is flexible, transparent, and easily extensible. We represent a fault discontinuity through a stress-accurate implementation in a mixed FE elastic formulation, which exposes the prescribed slip explicitly in the variational form without using conventional split node and decomposition discrete approaches. To demonstrate the potential of this new computational framework, two examples are shown. Synthetic surface geodetic data are used to infer the coseismic slip distribution during megathrust earthquakes (linear inversion) and the crust and mantle Poisson's ratio (non-linear). While the estimation of the fault slip is crucial to understand seismic source processes and mitigate seismic and tsunamigenic hazards, the Poisson's ratio has been used as a proxy of presence of fluids and postseismic poroelastic effects. For the linear inversion, we compare our results with the standard linear approach where fault slip is inferred using elastic Green's functions. Such approaches require numerous forward computations, and do not allow resolving structure. These limitations may be overcome by adjoint-based optimization methods, which efficiently minimize the gradient of the cost functional. In this case, the computational time is independent of the number of model parameters. We compare eigenvalues and eigenfunctions of both approaches to gain insights on performance for the linear problem, and then explore the non-linear problem. Our inversion represents a novel technique to infer 3-D properties such as Poisson's ratio, often used as a proxy for fluid flow, in the crust and mantle wedge. Our approach has promise to explore more general inverse questions, such as to the best constitutive behavior, and might be helpful in future optimal experimental design and parametric sensitivity studies.

Keywords: Seismic cycle; Inverse theory, Numerical approximations and analysis, Earthquake source observations, Kinematics of crustal and mantle deformation

SETP
LCPHD

Finding a specific needle in a haystack: Tracing ejected zircon from the Chicxulub impact in K-Pg boundary sections

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Numerical modeling of the Chicxulub impact event on the Yucatán Peninsula in Mexico suggests that shockinduced ejection and vaporization of target lithologies into the stratosphere caused severe environmental stress, culminating in the K-Pg mass extinction 66 Myr ago. However, the exact timing and mechanisms of these impact cratering processes are not yet fully understood. To better constrain particle transport physics in impact ejecta models, it is crucial to incorporate more physical and chemical proxy data from within the Chicxulub impact structure and from the global K-Pg ejecta layer to bolster the current proxies (grain size, ejecta thickness, and the global iridium anomaly). We performed U-Pb detrital zircon (DZ) analyses on K-Pg boundary sites, to provide crucial “tracer” ages linked to distinct pre-impact and impact lithologies, which can be used as an input parameter in ejecta models. Chicxulub target rocks include a newly dated ~334 Ma magmatic arc uplifted within the peak ring as well as the well-known ~550 Ma Yucatán basement age, previously studied in ejecta and suevite clasts within the crater. From the impact lithologies, researchers also recovered fully-reset 66 Ma grains. We investigated the K-Pg stratigraphy in multiple depositional environments (varying from deep marine to shoreface) and distances from the crater ranging from very proximal (<500 km) to intermediate (1000-3000 km). DZ signatures are complicated by competing impactinduced processes: mass gravity flows induced by earthquake surface waves which travel at ~3 km/s), cratersourced ejecta ballistically emplaced in proximal sites (<3 km/s) or following atmospheric transport and mixing in more distal sites. Tsunami can also transport marine-emplaced ejecta and rework previously deposited material (<0.2 km/s). K-Pg boundary samples show DZ signatures of Upper Cretaceous sediments typical of each region suggesting that these sediments were mobilized by earthquakes and/or reworked by tsunami waves. More importantly, we discovered ages that “fingerprint” the crater: 66 Ma, the most abundant “tracer” age in all sites, and sparse Yucatán basement ages in the intermediate sites. The careful differentiation of these ages is critical to understanding the mechanisms that govern the K-Pg stratigraphy at each site including ejecta emplacement and erosion/deposition of Upper-K sediments.

Keywords: impact crater, mass extinction, ejecta, zircon

SETP
LCPHD

The source of chlorine isotope heterogeneity in mid-ocean ridge basalts

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Previous calculations of the chlorine isotope composition ($\delta^{37}\text{Cl}$) of the depleted mantle (DMM) range from -3.0‰ to +0.9‰, spanning most of the terrestrial Cl isotope range. The reason for the inter- and intra-study heterogeneity is unclear but may result from contribution of Cl from subducted lithosphere with $\delta^{37}\text{Cl}$ values distinct from that of the peridotite mantle. Recycled crust, melt-metasomatized lithospheric mantle, and/or other components are subducted and subsequently mixed into the convecting upper mantle. These recycled components are thought to result in heterogeneity in MORB $\delta^{18}\text{O}$ values, radiogenic isotopes, and major/trace element compositions. Subducted components may retain significant quantity of Cl that contributes to Cl isotope heterogeneity in MORB. Different subducted lithologies have distinct ranges of $\delta^{37}\text{Cl}$ values and can be used to trace the subduction of different components into the convecting mantle. To determine the extent of subduction-derived chlorine isotope heterogeneity in the DMM, the chlorine isotope compositions of wellcharacterized pristine MORB glasses with no evidence for seawater or brine assimilation were analyzed for Cl contents and chlorine isotope compositions. These glasses span the range of chemical compositions of MORB from enriched to depleted.

A preliminary compilation of these new data and previous $\delta^{37}\text{Cl}$ data shows a wide range of $\delta^{37}\text{Cl}$ values in MORB (>+0.5‰ to <-1.2‰). Within and between each dataset there is a strong negative correlation between $\delta^{37}\text{Cl}$ values, indices of enrichment (La/Sm, K/Ti), and indices of degree of melting ($\text{Na}_{8.0}$). Additionally, there is a weak positive correlation between $\delta^{37}\text{Cl}$ values and $^{143}\text{Nd}/^{144}\text{Nd}$, and a weak negative correlation between $\delta^{37}\text{Cl}$ values and $^{87}\text{Sr}/^{86}\text{Sr}$. While some of these trends are consistent with chlorine isotope fractionation during melting, the high incompatibility of Cl, the small isotopic fractionation coefficient of Cl at high temperatures, and the observed correlation between $\delta^{37}\text{Cl}$ and radiogenic isotopes make this possibility unlikely. Instead, the observed correlations are consistent with mixing between subducted altered oceanic crust with $\delta^{37}\text{Cl} < -1.2\text{‰}$ and depleted peridotite with $\delta^{37}\text{Cl} = 0\text{‰}$ to +0.5‰.

Keywords: mantle heterogeneity, MORB, volatile, chlorine, isotope, subduction

SETP
LCPHD

Tropospheric Artifact Estimates to Optimize InSAR Time Series Without In Situ or Weather Model Information

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Interferometric Synthetic Aperture Radar (InSAR) solutions derived from different subsets of interferograms over the same region should be consistent. But in practice, measurement errors, such as those from tropospheric noise, can vary widely in magnitude and distribution depending on which specific scenes are used. The increasing quantity and quality of InSAR data makes it possible to accurately estimate tropospheric noise directly from the data and quantify and reduce its impact on InSAR time series solutions.

In this study, we characterize the tropospheric noise in 95 Sentinel-1 SAR scenes over the Oman Ophiolite. By averaging all interferograms sharing a common date, we approximate the tropospheric noise on that day. We find that on days with large tropospheric signal ($>7\text{cm}$), the tropospheric noise estimates are apparent using only 10 interferograms. For days with smaller tropospheric signals, we find that accurate estimates require ~ 50 interferograms. In the Omani desert measurements, we observe tropospheric signal artifacts $>10\text{ cm}$ that may persist for several SAR acquisition days. When analyzed using a constant velocity model, the time series depends further on how tropospheric noise is weighted differently in different subsets. This can appear as a 6 cm uplift signal that fades over time as the “bad” days become confined to the middle sections of the available data. To avoid overweighting tropospheric noise, we track tropospheric noise and remove turbulent SAR images in subsequent analysis and quantify the uncertainty of different subsets. We no longer see a 6 cm uplift signal, and InSAR solutions derived from different subsets are more consistent. Our approach provides a new way to derive InSAR uncertainty analyses in areas and can be applied without requiring in situ validation.

Keywords: InSAR, troposphere estimates, remote sensing

SETP
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The Mojave-Sonoran Desert triple divides: four major paleorivers emanated from a rapidly exhuming Laramide hinterland

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The Laramide landscape of the Mojave and Sonoran Deserts, where the flat slab impinged on the margin of North America, has been extensively overprinted by Basin and Range extension leaving the nature of the Laramide landscape a largely open question. We use detrital zircon U-Pb-He double dating from Upper Cretaceous–Eocene strata of the Tornillo basin, west Texas and the Rio Grande embayment, south Texas, integrated with a compilation of published detrital zircons from the Cordilleran forearc, the Laramide province of the western United States, and the Gulf Coast to reconstruct paleodrainages out of the Laramide Mojave and Sonoran Desert region, elucidate the region's Laramide exhumation history, and reconstruct Laramide hinterland landscape morphology and topography in response to flat slab subduction. We determine that four major paleodrainages—the Transverse Ranges forearc drainages, the California river, the Tornillo river-paleo Rio Grande, and the La Popa river—emanated from a relatively narrow region of the Mojave and Sonoran Deserts. Detrital zircon (U-Th)/He dates show short lag times for Cordilleran and Laramide arc plutons indicating that the arc and retroarc were rapidly exhuming. This demonstrates that the Laramide Mojave and Sonoran Desert landscape was a rapidly exhuming, well-drained, mountainous highlands characterized by a mix of volcanics and exhuming arc plutons, sedimentary rock, and cratonic basement. This landscape was highly dissected by major paleodrainages and must have contained at least one continental triple divide that separated drainages to the Pacific Ocean, Lake Uinta, and the Gulf of Mexico.

Keywords: Detrital zircon U-Pb-He double dating; Laramide orogen; Sedimentary Provenance; Landscape Evolution

SETP
LCPHD

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

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The Gulf of Mexico (GOM) is an important basin in the tectonic evolution of North America, whose evolution has been recorded in the offshore and onshore stratigraphic records of southern US and eastern and south Mexico. Early Mesozoic basins along eastern Mexico have been linked to the disgregation of the supercontinent Pangea and the opening of the GOM. However, the architecture and timing of the early syn-rift Mesozoic basins in southern Mexico is still lacking resolution. In the northern Sierra Madre de Chiapas, early Mesozoic continental siliciclastic strata, previously assigned to the Todos Santos Formation (Richards, 1963), allow enlightening the evolution and timing of pre-Oxfordian syn-rift strata, linked to westernmost Pangea break-up. New stratigraphic, petrographic, and detrital zircon (DZ) U-Pb provenance geochronology from the Concordia Basin presented in this study allows understanding the Todos Santos Formation rocks in order to link it with early Mesozoic basins along eastern Mexico.

The Concordia Basin (Molina-Garza et al., 2020) exposes volcanic rocks and siliciclastic sequences assembled in the Todos Santos Group. At the base of the TSG, the Early to Middle Jurassic volcanics and subordinate sandstone of La Silla Fm, overlay the metamorphic rocks of the Chiapas Massif Metamorphic Complex (CMMC) at the NW and SE of the basin. The basement of the basin is formed by the CMMC, and the Permian to Carboniferous Paso Hondo, Grupera, and Santa Rosa Formations. On top of La Silla Fm, the early Jurassic Juiquipila formation, previously known as Todos Santos Fm, is formed by 3 members: 1) red siltstone and fine sandstone of El Diamante member, 2) the coarse to medium sandstones of the Jericó member, and 3) the red beds of the Concordia member. The difference in lithology, the textures observed on the field, and local angular unconformities between these members suggest that they are related to episodes of syn-tectonic deposition after the emplacement of the early Jurassic volcanics and before the deposition of the Oxfordian San Ricardo Fm siltstone and anhydrite.

The DZ U-Pb maximal depositional ages (MDAs) confirm the deposition of El Diamante member during the Toarcian, followed by the deposition of the Jerico member, suggesting Middle Jurassic ages for the rocks of the Todos Santos Group. Such members have lateral continuity across the Concordia Basin. However, the Concordia member is only continuous in the northern sector of the basin. The Toarcian MDAs at the base of the El Diamante member and the Pliensbachian MDAs at the top of the Jerico member also suggests a progressive unroofing sequence and erosion of La Silla Fm. Furthermore, the differences between DZ age populations from such members suggest a change in sediment sourcing. Diverse Proterozoic and Paleozoic age populations of El Diamante member switch to dominant Permo-Triassic populations of the Jerico member. Thereby, the sources locally change from an initial sediment input from the CMMC that changes to a more dominant Chiapas Batholith and Jurassic Nazas Arc volcanics age populations.

The Early Jurassic ages of La Silla Fm match with the volcanic record and MDA's of syn-rift sequences in east Mexico like Huayacocotla, La Boca, Tezuitlán, and Matzitzzi; suggesting that magmatism at the Concordia Basin is coeval to rifting or back-arc extension. Additionally, the Toarcian MDA of El Diamante member suggests that such syn-rift rocks were also linked to late back-arc extension at westernmost Pangea, previous to the opening of the GOM. This new data allows enlightening the sedimentary response from extensional tectonics and permits to have better reconstructions of a key piece from western Pangea's disgregation.

Keywords: Todos Santos, Pangea disgregation, rifting, DZ geochronology, provenance

SETP
LCPHD

Evaporites Contents in the Chicxulub Impact Area

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In 1980 Álvarez et al.¹ proposed that the K-Pg mass extinction was related to the impact of an extra-terrestrial body on Earth. Several efforts were done to designate the impact area but neither the location nor the size of the discovered craters seemed to correspond with the worldwide geologic record interpreted as impact ejecta. In 1991 that Hildebrand et al.⁵ attributed magnetic and gravimetric anomalies to the buried Chicxulub impact crater, which was appointed as the responsible of such mass devastation.

Numerous efforts have been made in order to model and calculate the effects of the impact in the atmosphere that caused the extinction of > 60 % of the life form 66 Myr ago. The bolide encountered a ~3 km of evaporate rock layer over a 33 Km thick crust. This enriched sulfates environment favored the released of active gases into the atmosphere (Brugger et al., 2017⁴; Schulte et al., 2010⁷) which led to short-term cooling and long-term warming (Kring, 2007⁶)

Previous estimations proposed that 325 ± 130 Gt of sulfurs lead to a rapid cooling at the Earth's surface, while 425 ± 160 Gt of CO₂ added to the atmosphere contributed to longer-term warming (Artemieva et al, 2017²). The calculations were done using the information of anhydrite contents of the scientific well Yaxcopiol-1 and mapping the thickness of Cenozoic evaporates in six regional 2D seismic lines (Bell et al., 2004³).

We proposed to map the presence of anhydrite in the Yucatan platform where the information of >20 wells is available in order to provide the elements for future and more accurate estimations of the release of sulfures and CO₂. Our study will focus on the percentage contents of anhydrite in each well and the estimation of the thickness of this lithology in the studied area.

Keywords: Chicxulub,

SHP
LCPHD

Wood water content influences sap flux estimations under water limited conditions in a deciduous forest in Michigan

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Sap flux (SF) measurements are the most common individual-scale measurements and are used as a proxy for transpiration through the conservation of mass. While multiple heat-tracer style sensor types exist, the most broadly used are Granier-style thermal dissipation probes (TDP). Beginning in 2014, work at University of Michigan Biological Station pioneered continuously monitoring wood water content (WWC) using capacitance sensors in mature trees. This unique data set has been used to demonstrate the key role of stem-stored water, or the trees' capacitance, to buffer T against water stress. Furthermore, increasing evidence have shown diurnal variations between WWC of stems as results of changes in water reserves under laboratory conditions. These variations may induce inaccuracy in the nocturnal maximum temperature (T_{\max}) baseline of TDP underestimating SF readings. Therefore, it is critical to study the dynamics between WWC and SF measurements under natural conditions to establish these possible variations and its influence in the estimations of Transpiration.

We pair measurements of capacitance sensor measurements of WWC with SF observations made using traditional thermal dissipation probes in a mixed forest in northern lower Michigan. We demonstrated that decrease in WWC results in increase in the difference of the T_{\max} signal of the thermal dissipation probe under water stress or water limited conditions. This behavior is in accordance to the theory of heat conduction of solids. Our results suggest that diurnal dynamics in WWC may be an important source of errors in such conditions, and should be considered as a correction factor when applying the TDP method for long-term SF datasets.

Keywords: Sap flux, trees, water content, sensors, forest

U

Berryquake, an open-source Raspberry Pi-based seismometer.*Mason Currin**Becker, T., University of Texas Institute for Geophysics, Department of Geology, The University of Texas at Austin, Austin, TX**Currin, M., Department of Geology, The University of Texas at Austin, Austin, TX**Tisato, N., Department of Geology, The University of Texas at Austin, Austin, TX*

Seismic data acquisition is used to study earthquakes, and create subsurface imaging. Both of which are often performed with geophone and seismometers that convert the motion of the ground into readable electric potentials. Recent studies have shown that broad and dense networks of geophones can help scientists to better understand the seismic cycle or even anthropogenic activities. Nevertheless, seismometers are not available to the general public due to the difficulty of operation, and the hefty price tag. In order to make these devices affordable and open-source for the general public and the scientific community, we have created the BerryQuake, a Raspberry-Pi-based seismometer that costs only 300 dollars, a mere 30th the cost of a professional seismometer. We validated the accuracy of the BerryQuake to make it an effective tool for seismic research, education, and recreation activities. With the cheap price tag, BerryQuakes could easily find its way into the hands of scientists and the general public, where it could become integrated into global sensing networks. Having a widespread network of sensors would allow for pinpoint earthquake detection corroborating earthquake/tsunami early warning networks, informing monitoring and warning systems for social events and vehicular traffic, and even helping detect/predict rockslides or avalanches.

We compared the performance of a BerryQuake to a professional seismometer (MBB-2, Kinometrics) by recording thousands of hours' worth of passive seismic signals between 2018 and 2019. Measurements were performed by recording the noise from normal UT Austin activities and football games, while both instruments were placed in a closet inside the UT Austin stadium. We developed Matlab scripts to process and analyze data from both instruments. Loud events, such as people cheering during a touchdown correlate very well both in-phase and amplitude. [TN1] The two datasets are very close in terms of peak amplitudes and time series envelopes. However, upon close analysis of the spectrograms, we can observe the broader frequency bandwidth (0.008 – 100 Hz) and greater definition of the signals recorded by the MBB-2, whereas the BerryQuake spectrogram reveals not as defined and broad in frequency, i.e., 10 - 250 Hz. Despite the lower quality of the data recorded by BerryQuake, results are very similar in the frequency bandwidth 10 - 100 Hz. BerryQuake frequency bandwidth could be extended down to 4.5 Hz with no price or design modifications. Considering the cost-benefit, we believe that the comparison of the performance of the two instruments makes the BerryQuake a viable tool for research, especially in consideration of widespread deployment.

Keywords: Seismology, Raspberry Pi, Football

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Chlorine and Fluorine Abundances of Hydrous Minerals in Colorado Plateau Mantle Xenoliths: A Step Towards Quantifying the Mantle Halogen Budget

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The subcontinental lithospheric mantle (SCLM) is thought to be a sink for volatile elements, including the halogen elements of chlorine and fluorine; however, quantifying the concentration and distribution of halogens within the SCLM is poorly constrained. In this study, we combine petrologic observations with geochemical analyses of hydrated mantle xenoliths from the Navajo Volcanic Field (Colorado Plateau, USA). We use XRD and EMPA to identify the modal mineralogy and the Cl and F concentrations in hydrous minerals. Multiple generations of hydrous minerals are observed, including high-pressure, mantle-derived serpentine, chlorite, and amphibole, as well as secondary, low-temperature serpentine growing in late veins and along grain boundaries. Petrologic observations, confirmed by XRD analysis, show these peridotites contain 20% to 80% hydrous minerals, with serpentine typically the dominant phase. Each hydrous phase was analyzed by EMPA for Cl and F concentration, with detection limits of 70 ppm and 140 ppm, respectively. Primary serpentine, amphibole and chlorite contain up to 400 ppm Cl, whereas the secondary serpentine was richer in Cl (1000-4000 ppm). Zoning in Cl concentrations was not observed. Overall, F concentrations in all measured phases averaged around the detection limit of 140ppm, with no observable preference for any specific phase. The Cl-rich primary serpentine, amphibole and chlorite in these xenoliths suggests interactions with a Cl-rich fluid during metasomatism within the SCLM, likely sourced from the subducting Farallon slab. The enrichment of Cl, but not F, is consistent with previous work proposing decoupling of Cl from F, wherein Cl preferentially partitions into the fluid while F is sequestered in the subducting slab (e.g., Straub and Layne, 2003; Kendrick et al., 2014). The highly Cl-rich secondary serpentine may form during interaction with late fluid/melt during subsequent emplacement.

Kendrick et al (2014) *Chem Geol* 370, 69-81 Straub and Layne (2003) *GCA* 67, 4179W203

Keywords: Halogens, Mantle, Deep Earth, Volatile Cycling, Subduction, Xenolith, Geochemistry

CCG

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Categorizing Variations of Phanerozoic Foraminifera*Katherine Faulkner**Faulkner, K., College of Natural Sciences, University of Texas at Austin; Department of Geological Sciences, University of Texas at Austin**Lowery, C., Institute of Geophysics, University of Texas at Austin**Martindale, R., Department of Geological Sciences, Jackson School of Geosciences*

Foraminifera are single-celled protists that evolved and diversified throughout the Phanerozoic Eon and are found throughout marine ecosystems. Different foraminiferal species' walls can be composed of organic and inorganic compounds cemented together, or they can be composed of calcium carbonate. These wall types are termed agglutinated and calcareous respectively. They are useful in paleo research because their shells, known as tests, can be used as proxies for environmental changes, and their high abundance makes them ideal for diversity studies. Foraminifera diversity and abundance are sensitive to a number of environmental and evolutionary factors, including ocean chemistry and climate. This research aims to classify the tests of foraminifera and look for potential trends throughout the geologic record. To accomplish this, the wall types—calcareous versus agglutinated – and life position were catalogued for over 47,000 foraminifera recorded in *The Paleobiology Database* (PBDB, <https://paleobiodb.org>); this new information compliments existing data, such as the paleogeographic location, species, environment of deposition, and habitat. The data was used to look for trends in the abundance and proportion of agglutinated versus calcareous through time using R Studio.

This initial data appears to have some biases. For example, the total abundance of foraminifera displays an extremely large peak around 72 million years ago (Late Cretaceous). In this peak, the overwhelming majority of samples come from marine foraminifera located in Northern Africa. Furthermore, there are many influential foraminiferal papers absent. The dataset is currently being expanded to include more foraminifera citations in the PBDB by adding more primary research papers to improve analyses of foraminifera diversity through time. This research discusses the current trends found in my preliminary research and the biases needed to be addressed within this database.

Keywords: foraminifera, paleobiology, paleontology, paleoclimate, paleoclimatology

CCG

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Ecologic assessment of a Late Pliensbachian and Early Toarcian benthic foraminifera assemblage from Central High Atlas, Morocco

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Reef communities experience several crises in deep time, primarily observed as a decrease in the diversity of their fauna. The Early Jurassic is punctuated by two intervals of significant reef fauna turnover: the Pliensbachian/Toarcian boundary event and the Toarcian Oceanic Anoxic Event. The degassing of the KarooFerrar-Chon Aike large igneous province in the Early Jurassic resulted in significant turnovers in reefal fauna on a global scale. A relatively continuous expanded record of carbonate platforms and ramps with reef deposits can be observed in the Central High Atlas Mountains of Morocco. In the Early Jurassic this region of Morocco was a newly-rifted, shallow portion of the Tethys Ocean. These shallow-water platforms and ramps provided optimal environments for the diversification of reef associations.

Foraminifera are a phylum of microscopic Protists that are highly diverse in their marine environments and interactions with other organisms. Benthic foraminifera occupying reefs are particularly important in studies of warming and acidification in deep time; the abundance and diversity of benthic foraminifera indicate the health of the reef, as these organisms have punctuated intervals of die-off that coincide with reef crises throughout the fossil record. Analyzing and understanding the changes in abundance of benthic foraminifera across the Pliensbachian/Toarcian boundary event and the Toarcian Oceanic Anoxic Event can provide for a better understanding of the evolution of the foraminifera assemblage and changes in the reef ecology. For my undergraduate thesis, I study and analyze the foraminifera of several Pliensbachian and Toarcian reefs in Morocco. The identified benthic foraminifera, to date, within my assemblage includes *Glomospira* sp., *Glomospirella* sp., *Siphovalvulina* sp., *Siphovalvulina colomi*, *Siphovalvulina gibraltarensis*, *Haurania deserta*, *Placopsilina* sp., *Mesoendothyra* sp., *Everticyclammina praevirguliana*, and members of either the genus *Vidalina* or *Ophthalmidium*. Shallow infaunal foraminifera belonging to the genera *Nodosaria* and *Fronidina* were also determined within these sections. The loss of large benthic foraminifera like *Mesoendothyra* sp. and *Everticyclammina praevirguliana* is evident locally after the Pliensbachian/Toarcian boundary event. Additionally, the extinction of *Haurania deserta* is observed within the post-Toarcian Oceanic Anoxic Event strata, which is consistent with published literature on the temporal range of this species. Small disaster foraminifera, despite being far less abundant following the two extinction events, dominate most of the assemblage. Although more sampling is necessary to provide a continuous record of abundance change between sites, we see evidence for reefs of high foraminifera diversity in the Late Pliensbachian shifting to a low foraminifera diversity assemblage following the Toarcian Oceanic Anoxic Event.

Keywords: foraminifera, paleoecology, reef, benthic, Morocco, extinction

CCG

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Identifying Micro-biomes and Biomineralization in Caves

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Caves have been considered a harsh environment for life for centuries because they are dark, have low nutrients, and sometimes have high concentrations of heavy metals and toxic gases. However, in the last decades, scientists have discovered a large variety of cave microbes actively involved in the formation of cave deposits, creating a long-term geologic record.

Many previously abiotically-explained cave formations have been reconsidered as biologically mediated. One of these formations are called helictites. Helictites are bizarre cave deposits with unique morphology and those found in a cave in France, Asperge, form in a harsh environment rich in heavy metals. A micro-biome has been found responsible for controlling their morphology in Asperge.

We found and analyzed helictites from the Breezeway cave in Colorado having a very similar morphology to those in Asperge. We performed the following analyses on 5 samples: X-ray diffraction and SEM Energy Dispersive Scanning for mineralogy; Micro-CT for morphology; and Scanning Electron Microscopy to investigate the presence of biofilms. More importantly, we performed DNA sequencing on microbial cultures developed from sediments and organic matter collected in three locations in Breezeway (1-3). Site 1 is the helictite site, containing structures found nowhere else in the cave. Sites 2 and 3 are control groups to compare the microbiome in these areas. Analyses suggest that the microbial community from Site 1 is similar to the Asperge site with helictites and contains incredibly larger amounts of microbial life than the other control sites. This suggests that microbial life is associated with helictite morphologies.

Our research helps recognize and understand life thriving in extreme conditions as a starting point for studying life on our and other planets. Given that caves are present on Mars and other planetary bodies, we suggest a potential way to search for past or current evidence of life in the geologic record.

Keywords: Geomicrobiology, geobiology, caves, karst, planetary, habitability, extremophiles, microbes

CCG

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Understanding Mid-Holocene ENSO Variability using Fossil Corals from Vanuatu*Eleanor Y. Cote**Cote, E.Y., Department of Geological Sciences, Jackson School of Geosciences, The University of Texas at Austin, Austin, TX, USA and Institute for Geophysics, Jackson School of Geosciences, The University of Texas at Austin**Partin, J.W., Institute for Geophysics, Jackson School of Geosciences, The University of Texas at Austin**Domeyko, R.A., Department of Geological Sciences, Jackson School of Geosciences, The University of Texas at Austin, Austin, TX, USA and Institute for Geophysics, Jackson School of Geosciences, The University of Texas at Austin**Taylor, F.W., Institute for Geophysics, Jackson School of Geosciences, The University of Texas at Austin**Lawman, A.E., Department of Atmospheric and Oceanic Sciences, The University of Colorado, Boulder, CO**Edwards, R.L., Department of Geology and Geophysics, University of Minnesota, Minneapolis, MN, USA**Cheng, H., Department of Geology and Geophysics, University of Minnesota, Minneapolis, MN, USA**Inoue, M., Department of Ocean Floor Geosciences, Atmosphere and Ocean Research Institute, The University of Tokyo, Kashiwa, Chiba, Japan**Nakedau, D., Department of Geology, Mines and Water Resources, Geohazards Section, Port Vila, Vanuatu*

The El Niño Southern Oscillation (ENSO) is a climate phenomenon caused by feedbacks between the ocean and atmosphere, occurring approximately every two to eight years. Large ENSO events change precipitation and temperatures patterns across much of the earth, causing large socioeconomic impacts. Unfortunately, there is large uncertainty how ENSO events will change under future anthropogenic forcing due to the increase in greenhouse gases. Data about past ENSO events can help to reduce the uncertainty on what controls the strength of ENSO events, thus providing constraints on how ENSO may change in the future. Corals in the Western Tropical Pacific are located in an ENSO sensitive region, making them excellent recorders of past ENSO events. Changes in the temperature and salinity of the ocean are recorded as geochemical changes in the skeletons of corals as they grow, and therefore older, preserved corals record changes about past ocean conditions. Climate models and coral data agree that ENSO was weaker 7000 years ago, although they disagree on the magnitude of the change (Lawman, et al., 2022). In order to reduce the uncertainty about past ENSO changes, we need data from other ENSO sensitive locations. Vanuatu is an ENSO sensitive region with abundant corals that record changes in ENSO (Lawman, et al., 2020a,b). We aim to reconstruct the variability of the El Niño Southern Oscillation during the mid-Holocene by collecting geochemical data from a fossilized *Porites lutea* core retrieved in 2005 at Araki Island, Vanuatu (15.62°S 166.95°E). The coral core is approximately 1.6 meters in length, and has been U-Th dated to 7,230 ± 440 y B.P. Using geochemical data collected from the coral, we can investigate monthly resolved variations in temperature and salinity of the surface-ocean conditions approximately 7000 years ago. The skeletal growth rate of the coral averages to be 1.3 centimeters per year, determined by growth rate banding and x-radiographic imaging of the coral. Using a micro-mill, we collect 12 samples to yield a geochemical data point representing every month of the year. We approximate that the complete coral record will present approximately 90 years of data once sampling and geochemical analyses are finalized. Future work includes examining additional corals from different time periods to investigate trends in ENSO variability over the Holocene. This may be done by sampling another fossil coral sample previously collected from Vanuatu to compare this coral record.

Keywords: El Niño, Coral, Geochemistry, Climate Change

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Seismic data matching by least-squares non-stationary triangle smoothing*Reem Alomar**Alomar, R., The University of Texas at Austin**Fomel, S., The University of Texas at Austin*

We propose a fast and accurate method to estimate the non-stationary triangle smoothing radius for matching seismic datasets. The smoothing radius is estimated by non-linear least-squares inversion using an iterative Gauss-Newton approach. We derive and implement the derivative of the smoothing operator to compute the gradient for inversion. The efficiency of the proposed method is confirmed in several seismic data matching applications.

Keywords: seismic, processing, imaging, smoothing, regularization, matching

EG

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Predicting the Location of Uranium Deposits Using Surface Radiometric Data*Maya Niyogi**Niyogi, M., Energy Analytics FRI, The University of Texas at Austin, Austin, TX**Albert, M., Energy Analytics FRI, The University of Texas at Austin, Austin, TX**Queralt, S., Energy Analytics FRI, The University of Texas at Austin, Austin, TX**Chandhoke, R., Energy Analytics FRI, The University of Texas at Austin, Austin, TX**Rao, N., Energy Analytics FRI, The University of Texas at Austin, Austin, TX**Rachakonda, A., Energy Analytics FRI, The University of Texas at Austin, Austin, TX*

Currently, the world is at an environmental crossroads; the energy crisis is a topic at the forefront of every conversation. Greenhouse emissions trapped in the atmosphere have raised the Earth's annual average temperature, preventing life from being maintained as it was in previous decades. As a result, many are looking to switch to greener sources of energy to reduce carbon and other emissions in the atmosphere.

Our group predicted that nuclear energy could be a potential alternative, seeing as its usage has steadily been increasing since the 1970's and has few emissions, if at all. The data we used, titled CLOVIS, was collected in 1976 on the border of New Mexico and Texas by the USGS, and each data point corresponded with a single geographic location. Contained in this dataset were latitude, longitude, altitude, radiometric values and magnetic-field values. Additionally, there were geologic symbols detailing the area in the data sets. The aircrafts tracked the locations of Uranium, Thorium, and Potassium, but we chose to focus on Uranium. Our project focused on locating these Uranium deposits on this border through a neural network. Our algorithm aims to expedite the process of finding sources of Uranium and other elements using aeroradiometric data, which is beneficial as it will lower mining costs and effectively increase supply. Since the data came with latitude and longitude coordinates, we created testing and training data groups using spatially constrained agglomerative hierarchical clustering. Our neural network was a feedforward regression-based network with the overall purpose of estimating the amount of Uranium (ppm) at a specific location. Our resulting model was able to give adequate estimates of concentrations at specific locations with an average prediction difference of 33.6 ppm. 77.3% of the predictions were within 50 ppm and 97.8% of the predictions were within 100 ppm.

With the way our network was formatted, it can be repurposed and retrained to predict the concentrations of different elements, such as Thorium (which was included in the CLOVIS data). It could potentially be adapted to predict concentrations of specific elements in different water bodies, such as calcium or magnesium which result in hard ground water, inconducive for drinking purposes.

Keywords: geostatistics, neural networks, machine learning, data science, nuclear energy, energy, Freshman Research Initiative, undergraduate, uranium,

SETP

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Investigating the History of the Menderes Massif (Western Turkey) Using Electron Backscatter Diffraction*David Keith**Keith, D., The University of Texas at Austin, Austin, TX**Catlos, E., The University of Texas at Austin, Austin, TX**Orlandini, P., The University of Texas at Austin, Austin, TX**Cemen, I., The University of Alabama, Tuscaloosa, AL*

The Menderes Massif in western Turkey has global importance due to its role as the largest zone of active continental extension on Earth. The region is located at the boundary between the Aegean and Anatolian microplates and is considered a type-location for marking a significant transition between contractional and extensional tectonics across the Alpine-Himalayan chain. The Menderes Massif was exhumed via large-scale extension since the Tertiary. Low-angle detachment faults and high-angle normal faults bound the massif's sedimentary basins and separate the Menderes Massif into northern, central, and southern submassifs. Here we report optical petrography and electron backscattered diffraction (EBSD) data from rocks collected along the low-angle Alasehir detachment, which bounds the northern edge of the central massif. We also obtained data from the Kucuk Menderes Graben and its southern boundary (Buyuk Menderes Detachment).

Optical petrography and EBSD of all samples in the study quartz and feldspar through abundant subgrain rotation and minor bulging recrystallization, respectively. All samples record prism slip in quartz from subgrain rotation axes, indicating temperatures of deformation from 500-650 °C. From the northern side of the graben, recrystallized quartz grain size piezometry indicate paleostresses increase from 37 MPa to 68 MPa from south to north towards the Alasehir detachment. Samples taken from the floor of the graben record paleostresses of 66 MPa, and sample from the southern end of the graben record consistent 51 MPa as they traverse south towards the Buyuk Menderes Graben. The analysis of petrographic microstructures from these samples combined with EBSD datasets was used to generate petrological P-T-t-d data to match deformation mechanism, paleopiezometry, and kinematics with tectonic models.

Keywords: Metamorphic core complex, faulting, electron backscatter diffraction, microscopy

SHP

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Source to Sink: Tracking Tire Microplastic Pollution in Texas*Cole Carrabba**Carrabba, C., The University of Texas at Austin, Austin, TX**Gearon, J., Indiana University - Bloomington**Olariu, C., The University of Texas at Austin, Austin, TX*

Microplastics are plastic particles smaller than 5 mm that are formed from degradation of larger plastic objects (secondary microplastics) or are created as small particles in beauty products, abrasive materials or plastic main components (primary microplastics). Tires are a significant but relatively understudied source of primary microplastics which emit individual particles typically ranging from 5 μm to 220 μm . We quantified microrubber pollution generated along Texas roads using calculations related to the weathering rates of tires. The state of Texas contains approximately 22 million registered vehicles which drive over ~680,000 miles of roads every year. Using the 2019 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. Critical to our calculation is the amount of microplastic rubber generated by tire consumption for one tire. By using the difference between used and new tire weights with estimated yearly mileage and corrected with tire tread decrease, after measurements of more of 200 tires, we estimate passenger vehicles (Light Duty) emit approximately 0.028 g/km of microrubber particles on average for one tire (with first quartile at 0.011 and third quartile at 0.039 g/km), for one car (4 tires) that is 0.112g/km. Commercial vehicles (Heavy Duty) emit 10x more (1.12 g/km) on average according to published studies. Our calculations unsurprisingly indicate that the spatial variability of microplastic rubber in Texas is linked with large metropolitan areas such as Houston, Dallas-Fort Worth, San Antonio, and Austin which are pollution hotspots (all 4 together generate more than 50% of Texas rubber waste) due to large numbers of cars and dense road networks. Major thoroughfares are likewise a large contributor to tire-based microplastics. Using the average tire consumption estimates, our research quantifies the tire waste produced on Texas' roadways at about 240,000 metric tons in 2019. All of this material is blown by the wind or washed through the creeks and rivers of Texas where it might locally accumulate and reach high concentrations. We also segment pollution hotspots along roads using river watershed maps in order to estimate areas of risk. A clearer picture of tire pollution will aid future research and creative solutions to Texas' microplastic pollution.

Keywords: microplastic, plastic pollution, particulate matter

SHP

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Modeling Tsunami Deposit Grain Size Trends Using Particle Tracking: Implications for Flow Inversions*Junwoo Kim**Kim, J., Environmental Science Institute, The University of Texas at Austin, Austin, TX**Johnson, J., Department of Geological Sciences, The University of Texas at Austin, Austin, TX*

Tsunamis are some of nature's most catastrophic events, displacing great amounts of water, sediment, and people alike. Sediment deposits left behind by these rare but extreme events are often the only records of their occurrence. Deposit characteristics - especially grain size distributions (GSDs) - can, in principle, be used to put bounds on flow magnitudes, wave heights and velocities. However, there are many uncertainties in how the flows transport and sort sediments due to innate difficulty in direct observation. We developed a model tracking the motion of particles in the water column to gain a better understanding of grain advection, dispersion, and the GSDs deposited by tsunamis.

In our model, we explicitly impose and adjust variables including turbulent fluctuations, mean velocity and velocity profiles, bedload and resuspension probabilities, and source particle GSDs and positions, and measure the effects on particle trajectories and deposition. We compare the particle-tracking model results to controlled laboratory experiments to better interpret experimental trends. We also use the particle-tracking model outputs of deposit grain size distributions as inputs for an advection-settling inversion model for flow depth and velocity, in order to systematically evaluate how different variables (turbulent dispersion, resuspension, etc.) influence paleoflow predictions.

Preliminary results suggest that a single deposit grain size percentile (e.g., D50) does not provide an accurate prediction of flow depth and velocity along the deposit, but that the best-fit deposit percentiles change with transport distance. Different vertical profiles for the mean velocity appear to have relatively little impact on deposit particle distributions. However, inverse model results are fairly sensitive to downstream transport by bedload and resuspension. By using our model to systematically vary parameters that are difficult to control in physical experiments (e.g., turbulence, resuspension probabilities), we hope to better unlock interpretations of paleotsunami and storm surge hydrodynamics from their deposits.

Keywords: Tsunami, Particle Tracking, Modeling, Grain Size Distribution

SHP

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Thermal and Chemical Stratification of Lake Travis*Morgan Teel**Teel, M., Department of Geological Sciences, The University of Texas at Austin, Austin, TX**Ngyuyen, W., Department of Geological Sciences, The University of Texas at Austin, Austin, TX**Demir, C., Department of Geological Sciences, The University of Texas at Austin, Austin, TX**McKinney, T., Department of Geological Sciences, The University of Texas at Austin, Austin, TX**Mehr, J., Department of Geological Sciences, The University of Texas at Austin, Austin, TX**Cardenas, M. Bayani, Department of Geological Sciences, The University of Texas at Austin, Austin, TX*

Lake stratification patterns are important in understanding how the biogeochemical ecosystem in a lake changes throughout the year. To understand and begin tracking the stratification pattern of Lake Travis in Austin, Texas, we profiled the lake once a month over a 12-month period from October 2020 to October 2021. Lake profiling was facilitated by scuba diving to a depth of around 40 m with sensors that measured temperature, pH, dissolved oxygen (DO), dissolved carbon dioxide, specific conductivity, fluorescent dissolved organic matter (fDOM), and turbidity. Samples of water were collected from the surface and the bottom of the lake for further chemical analysis to determine concentrations of major ions and identify trends in the chemical stratification of the lake. The twelve-month testing period showed Lake Travis to be a monomictic lake where there is only one complete turnover per year. The thermal stratification of the lake appears to occur between April to November with turnover from December to March. Differences in chemical composition between the surface and bottom water samples also indicates a chemical turnover period from January to March.

Keywords: Lake stratification, turnover, chemistry, monomictic, water quality, epilimnion, hypolimnion