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EARTH AND ATMOSPHERIC SCIENCES

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EDITORS

Diana Krupnik completed her BS degree in Biology with a minor in Chemistry in 2012 and subsequently finished a degree in Geology in 2014 at the University of Houston. During her Bachelors, she completed a senior thesis in the field of remote sensing for vegetation studies. Currently, she is working on a PhD in geology, with a research focus in ground-based remote sensing used for detailed outcrop studies.

Joshua A. Flores completed a BS in Geology form Brigham Young University in 2013 and then worked with EGI at the University of Utah as a research assistant before beginning his PhD in Geology at the University of Houston. His research focuses on plate triple junctions and their roles in boninite petrogenesis under the direction of John Casey.

Dustin P. Villarreal (Student Research Day Committee Chair) received his B.S. in Geology from the University of Houston in 2012 and is currently a PhD candidate in geology under advisor Dr. Alexander Robinson. His research focus is understanding the origin, development, and deformation history of the upper continental crust in both convergent and divergent tectonic settings. His PhD project seeks to understand the Mesozoic history of the Pamir mountains. After graduating, he hopes to apply his geologic interest in understanding basin evolution for oil and gas production.

Regina M. Capuano (Faculty advisor for Student Research Day) is an Associate Professor of Geosciences at the University of Houston. She completed her PhD in Geology at the University of Arizona.

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Oral Presentations

FIBER OPTIC MOTION SENSING: A COMPARISON OF DAS, FBG, AND GEOPHONE SENSORS

ALFATAIERGE, Ezzedeen
Li Chang
Nikolay Dyaur
Michael Ho
Robert R. Stewart

Geophysical data acquisition has found substantial value in using optical telecommunication fibers to achieve VSP and microseismic analysis via Distributed Acoustic Sensing (DAS). However, a limitation of conventional DAS is it's the uniaxial strain measurements which lack sensitivity to motion perpendicular to the fiber direction. Fiber Bragg Gratings (FBGs) are fiber-optic sensors that can be oriented, which allow us to measure tri-axial strain relative to the three component displacement measurements. This study aims to establish a correlation and address the sensitivity of measurements in these two fiber-optic vibration sensors with respect to conventional geophones and hydrophones in land and marine environments. This study was conducted in a laboratory setting, using Instantel's Blastmate III 3C geophones to acquire the displacement measurements. The FBGS interrogator and fiber with three FBGs acquired the tri-axial strain measurements by wrapping the fiber on a PVC pipe and securing each FBG in three separate orthogonal directions. The Fotech interrogator was used on a single mode fiber wrapped around a PVC pipe to acquire DAS measurements. The instruments were placed in various environments: bare ground, a sand box, a gravel box, and a water tank. For the first environment, a vertical source was only used (a hammer on the ground roughly 60 cm away). The second and third environments were in a box, thus we are able to simulate shear sources in two orthogonal directions by striking the sides of the box. A hydrophone array was deployed along a pipe with DAS fiber in the water tank. The geophone data show that ground coupling influences the data amplitude and frequency dramatically, and the fiber data is more comparable to the spiked geophone. Thus we can conclude that through surface placement of the fiber, we achieve sufficient coupling to measure the disturbance generated by the source. Finally, the frequency content of both systems is similar, however, the amplitude response requires proper conversion from strain to displacement in order to make a sound judgment of the amplitude fidelity.

EXTRACTING FAULT AND REGIONAL SALT FLOW INFORMATION FROM A HIGH-RESOLUTION, BATHYMETRIC MAP OF THE SLOPE AND ABYSSAL PLAIN OF THE US GULF OF MEXICO

BUGTI, Muhammad Nawaz

GIS tools and neural networks were used to analyze a 1.4 billion pixel, 145,000 km2, high-resolution, bathymetric map of the US GOM that was prepared by the Bureau of Ocean Energy Management (BOEM) using the bottom return from merged, industry 3D seismic surveys. Workflow adopted for extracting active faults data includes: 1) creation of ArcMap GIS project from BOEM bathymetry map; 2) GIS spatial analysis from the bathymetry to create slope and hillshade maps; 3) extraction of surficial faults and surficial fault scarp dips from neural network analysis; and 4) determination of fault offsets with 2D seismic reflection data. The main results from the fault map include the following: 1) in contrast to the result of a previous study that proposed on the basis of surficial faulting and minibasin shapes that regional GOM salt motion is to the southwest, we conclude that the main direction of salt transport is to the south and south-southeast; this direction of transport is consistent with the controlling influence of the deepest area of the GOM basement in in the area below and to the south and south-southeast of the Sigsbee salt front; 2) this displacement direction can be used with the “bow and arrow rule” to calculate the frontal thrust displacement of salt lobes varying from 41 to 146 km; 3) salt lobes are controlled by the presence of deeper-penetrating minibasins that act as an obstructions in the forward motion of the salt front as proposed by previous workers; 4) an overlay of 845 natural oil and gas seeps shows that the faults bounding minibasins are the main conduit for seeps probably as a result of the “plunger effect” of the minibasin through the underlying, hydrocarbon-bearing substrate; and 5) high-standing diapirs are confined to water depths of 70 to 2100 meters on the upper slope of the GOM and may reflect the erosive effects of the Gulf Loop current active at these water depths.

TRIPLE JUNCTIONS, BONINITES, AND A NEW MICROPLATE AT THE SOUTHERN TERMINATION OF THE MARIANA ARC

FLORES, Joshua A.
John F. Casey

A new microplate has been discovered while trying to correlate melting processes in subduction zones that are forming forearc and boninitic magmas along the southern part of Mariana Plate. The boundary between the Mariana plate and the Philippine Sea plate is along a well-defined back-arc spreading center for most of its length. The southern extension of this spreading center to the intersection with the Mariana Trench does not have a well-recognized morphological boundary. Previous work has hypothesized that subduction beneath a spreading center provides conditions required for boninite petrogenesis (Casey and Dewey, 1984, Dewey and Casey, 2011). Therefore, we attempt to locate the exact location of the trench-trench-ridge triple junction as it crosses the forearc and predict sites of potential modern forearc and boninite eruptions near the trench. The triple junction was defined using fault plane solutions to constrain the southern termination of the Mariana plate as it transects across the forearc to the trench. Normal faults suggest the triple junction to be at approximately 11.9N 144.1W, with slip direction of shallow subduction reverse faults dominantly at 290° north this junction and 205° south of the triple junction. While locating the southern boundary of the Mariana plate, the nucleation of a new 340° trending spreading center/rift zone in the remnant arc on the WPS plate creates a ridge-ridge-ridge triple junction between the forearc extension zone and the Mariana Spreading center. Discovery of these triple junctions isolates a piece of lithosphere that we interpret to be a new microplate that we name the Challenger Microplate.

GREEN'S FUNCTION OF THE WAVE EQUATION FOR A FRACTURED DISSIPATIVE HTI MEDIUM TAKING THE VISCOELASTICITY OF THE SYSTEM INTO ACCOUNT

GHOSH, Avradip
Evgeni Chesnokov

In this presentation we derive the Green's function of the wave equation for a fractured dissipative HTI medium. Inside the fractures there is a viscous fluid which adds to the attenuation of the wave. Previous works have been done for the elastic medium where the stiffness tensor have all real components. In this scenario the host rock and the fluid inside the fractures both have viscoelastic properties. Thus, complex terms in the stiffness tensor has been introduced to account for this viscoelasticity. Finally, we arrive to a Green Christoffel type of equation with additional complex terms due to the introduction of viscoelasticity. We then perform a Fourier Transform to solve for the Green's function and finally an Inverse Fourier Transform to obtain the Green's function in (x,t) space. This Green's function can be used to determine how a wave passing through a viscoelastic layer (e.g. hydrocarbon layer) is changed after passing through it. Thus, in turn it can be used to detect hydrocarbon layers.

TESTING MODELS OF EROSION IN THE HIMALAYAS

JOHNSTON, Shelby
Peter Copeland
Kurt Sundell

Detrital thermochronologic data is often used to infer catchment wide patterns of uplift and erosion. This is based on multiple assumptions, including steady-state thermal structure and topography throughout the catchment, uniform erosion, and representative sampling across the catchment. These assumptions are often violated in areas with significant tectonic activity. We will test these assumptions in the Narayani River Catchment in the Himalayas. When analyzing individual sub-catchments in the Himalayas, we can look at the enrichment of detrital samples from various thermochronologic units and compare this to the percent surface area of each unit within the catchment. This allows us to calculate enrichment factors of each thermochronologic unit, and show areas of increased modern erosion and detrital sampling. We can then test the assumption that all portions of a catchment are both uplifting uniformly and are proportionally represented in the detrital sample. This will allow us to compare modern erosion to stratigraphic, climatic, and tectonic variations across the catchment.

ROLE OF EOCENE-OLIGOCENE MASS TRANSPORT DEPOSITS FOR CONTROLLING ALONG-STRIKE VARIATIONS IN THICKNESS, STRUCTURAL GEOMETRY, AND HYDROCARBON SEALING, MEXICAN RIDGES FOLD-THRUST BELT, WESTERN GULF OF MEXICO

KENNING, Jack

The Mexican Ridges fold-thrust belt (MRFTB) of the western Gulf of Mexico (GOM) is a 600-km-long, deepwater fold-belt along the eastern continental margin of Mexico. The MRFTB formed as the down-dip contractional domain of a Miocene to Recent gravity-driven system, detaching on Eocene and Oligocene surfaces associated with multiple slumps, turbidites and mass transport deposits (MTDs). A 20,000-km grid of 2D seismic data was used to map the highly-deformed, shale-rich MTDs underlying the fold structures and document their along-strike variability in the MRFTB. Eight significant MTD events have been defined, ranging in thickness from 1500-m; the largest MTD extends >300-km into the GOM. Paleogene, Laramide-related uplift and Post-Laramide volcanic activity resulted in point-sourced, clastic sedimentary influx in the area of the MRFTB from paleo-river mouths along the eastern Sierra Madre Oriental. Uplift and tectonic instability along the margin resulted in slope failure and deposition of stacked MTDs with lobate geometries in map view. Paleogene deposits thickened by MTD's are less extensive in the southern MRFTB where MTD's rarely exceed 200 m thickness. The areas of the thickest MTD's are characterized by: 1) smaller, overlying fold wavelengths (2-7-km) and interlimb angles (50-105°) but larger fold amplitudes (0.35-1.05-km); 2) wider, arcuate fold pattern map view mimicking the shape of the underlying MTD; and 3) along-strike change in detachment depth from >7500-km in the MTD-thickened Paleogene section of the northern MRFTB, to 6500-km in the thinner, MTD-poor Paleogene section directly to the south. These along-strike variations in the MRFTB suggest that: 1) the MTDs remain fluid-rich and promote over-pressure that in turn controls the width and internal structure of the overlying thrust belt; and 2) over-pressured MTDs thicker than 150 m likely form regional seals for hydrocarbons generated in the underlying Mesozoic section, although locally thrust faults are present that may act as migration pathways.

WATER IN THE LITHOSPHERIC MANTLE WEDGE BENEATH THE NORTHERN CANADIAN CORDILLERA (ALLIGATOR LAKE)

KILGORE, McKensie
Anne H. Peslier
Alan Brandon

Assessing water contents of subduction zone mantle peridotites can gain insight into the compositions of slab-derived fluids/melts and the active margin water cycle. Here, 8 mantle xenoliths from Alligator Lake (northern Canadian Cordillera) are examined to address these issues. The harzburgites have less water, on average, but are more oxidized (ΔFMQ ~ 0.1) than the lherzolites (ΔFMQ ~ -1.0). The lherzolites have major and trace element compositions close to primitive mantle, while the harzburgite major element and heavy rare earth element (HREE) compositions are indicative of higher degrees of melt depletion, but with light rare earth element (LREE) enriched profiles. Correlations between lherzolite pyroxene water contents and bulk rock Ba/Nb and Ba/Yb ratios likely result from interaction with subduction related fluids. The trace element compositions of the harzburgite clinopyroxenes are successfully modeled by melting of a fertile mantle lithosphere and interaction with a carbonatite melt. Correlations between the harzburgite water contents and clinopyroxene Ca/Al ratios and Mg # are also consistent with the influence of carbonatite metasomatism. Metasomatism likely resulted from opening of a slab window beneath the region, detected as a low velocity seismic anomaly, which heated and mobilized a heterogeneous mantle lithosphere veined with carbonatite. This study confirms that subduction zone mantle lithosphere is not necessarily more water-rich or more oxidized than oceanic lithosphere or other off-cratonic settings. Moreover, local oxidation is not necessarily related to the ingress of subduction zone fluids but can also be related to melting of a heterogeneous lithosphere following heating above a slab window.

IMAGED AND PREDICTED MANTLE STRUCTURE OF THE SUBDUCTED IZANAGI-PACIFIC RIDGE UNDER EAST ASIA

LIN, Yi-An
Jonny Wu
Nicolas Flament

The intersection between a subduction zone and a spreading mid-oceanic ridge leads to a distinct gap or 'slab window' within a subducting slab. Seismic tomographic imaging of such gaps offers potential first-order constraints for convergent margin plate reconstructions, as contrasting plate tectonic models often show first-order differences in the reconstructed location and configuration of ridge-trench intersections. Along East Asia it has been proposed that the Izanagi-Pacific ridge subducted either: (1) sub-parallel (at low angle) to the entire Eurasian margin from 55 to 60 Ma, (2) at a high angle across South China and Japan in Cretaceous times, or (3) offshore along an intra-oceanic subduction zone and never subducted under Eurasia. We mapped a 4000 km-long, laterally-continuous and NE-SW trending slow tomographic 'slab gap' at ~750 km to 1200 km depth within the well-imaged East Asian mantle under present northern Sakhalin to central China. We used mantle flow models (Flament et al., 2017) to show that this mapped slab gap is the tomographic signature of the subducted Izanagi-Pacific ridge. The geometry of the slab gap and the subduction time inferred from slab unfolding both support subduction of the Izanagi ridge at low-angle between 60 and 55 Ma. Conversion of S-wave peturbations to temperatures using standard equations indicates the slab gap is 100°C to 300°C hotter than the surrounding Izanagi and Pacific slab lithosphere, which is in the range of the mantle flow model temperature field predictions. Our study shows that slab gaps from ancient ridge subduction events can be identified in seismic tomography models, and can persist within the mantle for at least 40 Ma. The mapping of this slab gap in tomography models could be used as a template to reconstruct other convergent margins.

STATISTICAL TOOLS FOR ISOTOPIC BIG DATA: ANALYSIS OF MID-ATLANTIC RIDGE BASALTS

LING, Xiang
McKensie Kilgore
Anne H. Peslier
Alan Brandon

Mid-ocean ridge basalts (MORB) have profound implications for the continuous melting of the ambient Earth's upper mantle beneath oceanic ridges. The significant geochemical heterogeneity in MORB has been revealed by radiogenic isotope ratios (Sr, Nd, Pb, and Hf). The aim of this research is to investigate the underlying physical reality of mantle sources by relating the multidimensional structure in the existing isotopic dataset and the segmentation of the mid-Atlantic Ridge. The dataset used for this study covers almost all the MORBs along mid-Atlantic Ridge (MAR), from 54.4ºS to 77.5ºN and 8.8ºW to -46.7ºW. The numerical technique of Principal Component Analysis is useful to reduce the linear dependence of the data to a minimum set of orthogonal eigenvectors encapsulating the information contained. The principal components PC1, PC2, and PC3 account for 60.309%, 30.785%, 5.024%, respectively, of the total isotope ratios variability. The samples with similar compositions to HIMU and EM and DM are identified to better understand the PCs. PC1 and PC2 are accountable for HIMU and EM whereas PC2 has limited control over the DM source. PC3 is more strongly controlled by the depleted mantle source than PC2. What this means is that all three principal components have a high degree of significance relevant to the established mantle sources. We also tested the relationship between mantle heterogeneity and sample locality. The dependent variable is the modified latitude where the samples were dredged. The principal component regression and PLS regression model the location based on 6 isotope ratios. Given the R^2, 87% of the variability of the dependent variable is explained by the 6 explanatory variables from both models. It means that the combined 6 isotopes are a strong predictor of geographic location along the ridge, a slightly surprising result. Statistical regression is a robust and powerful method for both visualizing and manipulating the multidimensional representation of isotope data.

3D FREE-AIR GRAVITY MODELING OF THE BARREIRINHAS AND CEARA BASINS, NORTHEASTERN BRAZIL

LUNN, Eric

The Barreirinhas and Ceara Basins of offshore northeastern Brazil cover a combined area of approximately 105,000 square km and form the northern and southern flanks, respectively, of the Romanche Fracture Zone (RFZ). The RFZ is a linear fracture zone with an average width of approximately 16 km that extends over 4500 km from offshore northeastern Brazil to its conjugate margin near offshore Ghana and Togo/Benin. During Aptian rifting of the equatorial Atlantic Ocean, the northeastern continental margin of Brazil rifted from the continental margin of West Africa. To better understand the present-day crustal structure and crustal thickness of the margin, a 3D free-air gravity model was created using 13,171 km of 2D seismic reflection data, 6 wells, 2350 km of wide-angle refraction lines and 6 refraction stations from previous workers, and public global topography as well as sediment thickness grids to constrain five horizons in the Barreirinhas and Ceara basins. These horizons produced 6 layers when input into the model and they are: 1) air, 2) water, 3) sediment, 4) upper crust, 5) lower crust and, 4) Moho. The well logs were used to determine a depth-density function for sedimentary infill, different densities were used for continental and oceanic crust, and seismic refraction data was used to add control to depths in the basement and Moho horizons within the model. Once the model was complete, a gravity structural inversion was calculated on the Moho horizon, in which the program takes into account the 3D model inputs and attempts to modify the Moho (changing crustal thickness) to best fit satellite derived free-air gravity data. A refraction constraint grid was also created and incorporated into the model to limit the extent to which the 3D modeling program was able to modify the Moho horizon in the inversion. The regional 3-D gravity model was used to estimate the location of the COTZ and test two possible models for rifting: 1) the presence of early rift, pull-apart basins at stepovers in a strike-slip-dominated system; and 2) the presence of unroofed exhumed mantle, in a magma poor system.

CONTROLS ON ORGANIC MATTER PRODUCTION AND ACCUMULATION DURING OCEANIC ANOXIC EVENT 2 IN THE CRETACEOUS LA LUNA FORMATION, NORTHWESTERN SOUTH AMERICA

PAEZ-REYES, Manuel
Peter Copeland
Humberto Carvajal
Carlos Molinares
Alan Brandon

The evolution of Earth's oceans during the Phanerozoic was punctuated by episodes of global ocean anoxia. The archetypical example of these events and focus of this study is known as the Cenomanian–Turonian oceanic anoxic event 2 (OAE2). During OAE2, black shales with high contents of total organic carbon were deposited in a wide range of marine environments causing a brief disruption of the global carbon cycle. Consistent with this disruption, isthe global occurrence of a δ13C positive isotopic anomaly in carbonate and organic substrates. Two contrasting hypotheses have been proposed to explain the initiation and expansion of ocean anoxia, protracted marine productivity, and organic matter production and accumulation during OAE2. On the one hand the oxygen minimum zone hypothesis states that enhanced organic matter production and accumulation resulted from strong upwelling of nutrients, high primary organic productivity, and intermittent benthic anoxic conditions. On the other hand the stagnant ocean hypothesis suggests that organic matter preservation and accumulation resulted from an increase in nutrient delivery and freshwater discharge to the basin causing salinity stratification and sustained anoxia of the bottom waters. The purpose of this project is to identify what of the aforementioned mechanisms controlled organic matter production and accumulation during OAE2 in the Cretaceous La Luna Formation using a combination of U-Mo concentrations as a proxy for benthic redox conditions, and marine palynology and palynofaciesto identify periods of enhanced nutrient delivery and fresh water input. Results from this research will help to better understand the controls on organic matter production and preservation during periods of extended anoxia and formation of source rocks.

FRACTURE CHARACTERIZATION USING MULTICOMPONENT ELASTIC WAVES

PENG, Xiaoyun
Yingcai Zheng

Fractures are pervasive structural features in the Earth's crust and they have a significant impact on reservoir management (drilling, well completion, etc.). Consequently, it is very important to characterize subsurface fracture system. Traditional non-seismic methods for natural fracture characterization, including detecting fractures from core and image logs and using data from well/production logging tests, could only measure fractures near the well borehole. In my research, I will use two forward modeling methods to probe subsurface fractures at the field scale. I will study the following three problems. (1) Under what conditions a fractured rock can be regarded as an equivalent anisotropic medium. In particular, how the interference of the fracture-scattered waves can give rise to the apparent anisotropy due to existence of fractures. (2) I will investigate P-to-P and P-to-S scattering and its relationship with equivalent seismic anisotropy. (3) I will investigate the above problems for uniformly distributed fractures in space distribution and use them to characterize the fractures, in terms of fracture orientation, spacing and compliance.

DEVELOPMENT OF SEDIMENT FABRICS INDICATIVE OF DEFORMATION PROCESSES IN GLACIAL DEPOSITS

ROBINSON, Delaney
Julia Wellner
John Menzies

The Ross Sea embayment is Antarctica's largest ice sheet drainage basin, comprising an area of more than 1.5 X 10^6 km^2. The sector receives input from both the East Antarctic Ice Sheet and the West Antarctic Ice Sheet and therefore sediment records of past glacial behavior represent a convolved signal of both ice sheets. The ice-bed interface is a complex coupled system comprised of unlithified subglacial material that deforms in response to applied glacier stress. The deformation processes drive the movement of the overlying ice mass and accounts for most of the ice stream flow velocity. The flow mechanism and sediments susceptibility to deform is related to the size, shape, and distribution of particles. The relatively recent deposits from the last glacial maximum (26.5-19 ka) in the western Ross Sea provide an opportunity for sediment core analysis within a precise geomorphic framework. Sample grain size, grain shape, grain texture, and detailed thin section fabric analysis reveal diagnostic microfacies associated with depositional and deformation processes. Sediment fabrics exhibit a range of strain levels reflecting ice sheet basal conditions during the last glacial maximum. Sediment core analysis within a controlled geomorphic framework provides confident facies identification with sediment properties that will be applied to cores that lack geomorphic context. Constraining substrate controls on ice sheet behavior over a regional scale provides a valuable tool for linking internal and external environmental influences, and thus can aid in predicting future ice sheet controls and variability.

JURASSIC-CRETACEOUS STRATIGRAPHIC AND STRUCTURAL EVOLUTION OF THE NORTHERN YUCATAN MARGIN, GULF OF MEXICO BASIN

STEIER, Andrew

The Gulf of Mexico (GOM) basin formed during the Triassic to late Jurassic first phase of rifting as the Yucatan continental block rifted southeast away from its northern GOM conjugate margin. During a second, late Jurassic to earliest Cretaceous drift phase, the Yucatan block rotated counter-clockwise to its current location and produced an eastward-narrowing wedge of oceanic crust beneath the central GOM. The stratigraphy and structural evolution of the Florida margin is much better understood than its northern Yucatan conjugate because previous hydrocarbon exploration has been more extensive on the Florida margin than on the Yucatan margin. In the northeastern GOM, the late Jurassic section near De Soto Canyon records late Jurassic-Cretaceous gravity sliding and downdip dispersion of rafted blocks along a basinward-dipping layer of salt. This study uses a 117,000 km2 grid of 2D seismic data tied to published regional seismic lines and wells to describe a previously unrecognized and coeval area of widespread gravity sliding along the northern Yucatan margin. I define three structural domains based on their unique salt structures and resulting deformation: 1) the northeastern study area consists of relatively undeformed, late Jurassic-Cretaceous section underlain by minimal salt; 2) areas in the central and southwestern study area contain late Mesozoic gravity slides defined by normal faults rooted onto a 1-4º basinward-dipping salt detachment that controlled overlying, sedimentary growth wedges separated by intervening, 300-900 m-thick salt rollers; and 3) the distal margin of the western and central study area exhibits large salt diapirs that penetrate overlying units as young as the Pleistocene. In the central area containing late Mesozoic gravity slides, a sedimentary unit equivalent to the productive, Oxfordian Norphlet sandstone of the deepwater northeastern GOM is identified based on its similar seismic character. Reconstructing the Norphlet-equivalent unit to its location during Oxfordian deposition places it adjacent to an extensive area of deepwater Norphlet sandstone mapped in previous studies. The reconstruction suggests an 81,000 km2 fairway of potential aeolian, Jurassic reservoirs on the Yucatan and Campeche margins that includes areas of productive reservoirs in the southeastern Bay of Campeche which previous authors correlated with the Norphlet Formation.

SPATIOTEMPORAL VARIATIONS OF SATURN'S ZONAL WINDS BASED ON CASSINI LONG-TERM (2004-2017) MULTI-INSTRUMENT OBSERVATIONS

STUDWELL, Aaron
Liming Li
Xun Jiang

The recently completed Cassini mission spanned thirteen years, providing scientists data and images that will expand our insight into Saturn for decades to come. The Cassini spacecraft carried a complex suite of instrumentation onboard, specifically designed to provide imagery deep into Saturn's atmosphere. The Composite Infrared Spectrometer (CIRS), the Imaging Science Subsystem (ISS), and the Visual and Infrared Mapping Spectrometer (VIMS) were specifically designed to observe from upper troposphere up into the stratosphere. This research will be conducted to examine spatiotemporal patterns in the Saturnian atmosphere, extending across the troposphere and stratosphere. Additionally, this research should yield a better insight into the seasonality of Saturn's jet structure. This Dissertation will be divided into three tasks: 1) Examine spatiotemporal patterns in the upper tropospheric winds on a global basis, i.e., extending from pole to pole, as measured by the VIMS; 2) Utilize data from the Cassini's Imaging Science Subsystem (ISS) and the Composite Infrared Spectrometer (CIRS) to examine spatiotemporal patterns in the upper troposphere, across the tropopause, and into the stratosphere; 3) Utilize combined data of the multi-instrument observations from the CIRS, ISS and VIMS platforms, examine spatiotemporal variations of Saturn's atmosphere during the time period of 2004 through 2017

OSMIUM ISOTOPES, PLATINUM-GROUP ELEMENTS (PGE) AND RHENIUM IN SEDIMENTS ACROSS THE YOUNGER DRYAS(YD) BOUNDARY FROM HALL'S CAVE, TEXAS

SUN, Nan
Alan Brandon
Steve Forman
Michael Waters
Thomas Stafford Jr.

Hall's Cave, Texas provides a unique opportunity for testing a chronostratigraphic datum(a distinct lithologic contact), previous studies indicate this layer contains carbon spherules and enlogaes, magnetic grains and spherules, nanodiamonds, with a controversial derivation from cosmic impact ~12,900 ka. This impact hypothesis suggests that extraterrestrial object(s) hit and exploded over North America, triggered the onset of YD cooling and widespread megafaunal extinctions and the demise of the Clovis archeological culture. An elevated concentration of carbon spherules and enlogaes, magnetic grains is reported as supporting evidence, one geochemical indicator, Ir-enrichment has been reported, but the lack of reproducibility the age of the Ir layer at different locales has been problematic with the impact event at the YD period. Thus isotope geochemical analysis has not been targeted enough to make a robust argument for the impact hypothesis. The integrated method of using PGE and Re and Os isotopic ratios is of great importance for the detection and identification of ET projectiles in terrestrial deposits. Less than 1% of ET materials can provide enriched PGE concentrations. This makes the PGE an ideal tool for studying extraterrestrial input of impact materials associated with terrestrial craters. Because of the large difference between chondritic and terrestrial 187Os/188Os ratios, ~0.127 and >1.4, respectively, the 187Os/188Os ratios are highly sensitive indicators of an extraterrestrial component in terrestrial and marine sediments. For samples at different time layers in and near the YD boundary layer, we observe 187Os/188Os ratios of 0.11-0.42, with PGE patterns resembling upper continental crust (UCC) but with an uptick of Os abundances that are up to two orders of magnitude higher than UCC. Some of these samples have upticks in Ir abundances as well. Reduced 187Os/188Os ratios of 1.49~1.57 are present in some of the layers adjacent to those showing these low Os ratios. When compared to the 187Os/188Os "base value" which is 2.02~2.45, these indicate an addition of material with non-radiogenic 187Os/188Os ratios. Multiple layers with low 187Os/188Os ratios would require multiple impacts which is an unlikely scenario on a short (1000 ka) timescale, instead examine whether this can be the result of volcanic eruptions.

SHEAR WAVE VELOCITY STRUCTURE BENEATH EASTERN NORTH AMERICA FROM RAYLEIGH WAVE TOMOGRAPHY

TAO, Zhongmin
Aibing Li
Yao Yao

The Geology of eastern North America is characterized by distinctive tectonic terranes, including the Grenville Province, the Appalachian Orogen, and the passive Atlantic margin. To investigate how the lithosphere has evolved through the orogenesis and rifting process, we construct shear wave velocity models from Rayleigh wave tomography using a two-plane wave inversion method. Fundamental mode Rayleigh wave data from 114 earthquakes recorded at 208 USArray Transportable Array stations are analyzed and inverted for phase velocities at periods of 20 to 167 s. These phase velocities are used to develop the 3-D shear wave velocity model. The crust beneath the Appalachian Orogen is slower than under the Grenville Province, and the lowest anomalies are near the Atlantic coast. Velocity variations in the mantle do not correlate well with the geological boundaries on the surface. A high-velocity lithosphere to the depth of at least 150 km is found in the Grenville Province and the Appalachians in Pennsylvania. A continuous low velocity anomaly appears in the upper mantle of New England. This anomaly is on the track of the Great Meteor hotspot, which could have contributed to high temperature and mantle upwelling here at the first place. The initial upwelling has probably been maintained or strengthened by small-scale convection in the upper mantle.

IMAGING IMPROVEMENT IN ANGLE-DOMAIN COMMON-IMAGE-GATHERS BY A LOCAL STACK UTILIZING SEGMENTATION METHOD

THONGSANG, Pongthep
Hao Hu
August Lau
Hua-wei Zhou

Poynting vector based reverse time migration (PVRTM) can migrate seismic data into angle-domain common-image gathers (ADCIGs). The quality of common-image-gather is related to the used migration velocity. However, in the seismic data processing, we usually cannot obtain a very accurate depth migration velocity. The difference between the true depth velocity and estimated migration velocity would introduce image artifacts, which are often observed as non-flat events in the ADCIGs. These non-flat events will degrade the final image that is linearly stacked from all angles. To mitigate such image artifacts caused by the inaccurate migration velocity, we can use both quantitative and qualitative methods to optimize the stacking. The quantitative method uses a numerical method to achieve an optimal velocity model for migration. However, there is residual moveout error still left in the gathers. Instead, we propose a qualitative method to assure geologically meaningful result, so-called segmentation method using Moore neighborhood algorithm, which can decompose events in the ADCIGs into isolated signal groups. From this sequestered image domain, signals can manifest easier because of dealing only local signals that do not interfere with adjacent ones. We can automatically align concave events and focus stretching amplitudes at far angles. Additionally, we do not need cross-correlation to measure the moveout of non-flat events. Consequently, we can avoid the mismatching among the events at different depths. We test our proposed method by one numerical dataset. The numerical results show that the ADCIGs can correct the non-flat events in the AD- CIGs from small angle to large angle. Compared with the tradition RTM with Laplace filtering and small angle stacking, our new method can produce a superior migration image with fewer artifacts. In practice, this proposed method can reduce the requirement of migration velocity accuracy in the depth velocity building and provide a first-look of RTM image.

SEISMIC PROBING OF AN ASTEROID USING ONE SOURCE AND ONE RECEIVER

TIAN, Yuan
Yingcai Zheng

The interior composition of the asteroid is important to understand its origin and evolution. If a seismic source is detonated and a receiver listens the asteroid surface vibration, we can deduce important information about the interior. One salient feature about the asteroid is the highly irregular body geometry. To study seismic wave propagation and scattering in an asteroid, we need to be able to handle the topography. We have created a 3D Boundary Element Method (BEM) for this purpose. Our BEM code has been benchmarked with the analytical solution for an ideal sphere. For some asteroid, the topography is usually accurately mapped. With one seismic source and one receiver and by doing the modeling with the topography to fit the recorded seismogram, we can get a quick assessment about the average velocity and density for the asteroid. To test our procedure, we have done numerical modeling experiments to demonstrate the work under the influence of the large topography.

SEISMIC CHARACTERIZATION OF THE LATE CRETACEOUS SUBMARINE FANS SYSTEM IN THE DEEP-WATER FOZ DO AMAZONAS BASIN, NORTHERN BRAZIL: AN ANALOG FOR LATE CRETACEOUS FAN PLAYS ON ATLANTIC PASSIVE MARGINS

TORRADO, Lucia

The deep-water Foz do Amazonas basin shares the same working, petroleum system linked to the 2011 Zaedyus (700 MMbbl) and 2017 Liza field (800 MMboe) discovered in the French Guiana-Guyana-Suriname basins to the northwest: a Cenomanian-Turonian age source rock charging Late Cretaceous deep-water fan reservoirs. We conducted seismic facies analysis and geomorphology on the Late Cretaceous submarine fan systems (Limoeiro Formation) using 21,369 km of 2D depth-converted seismic tied to 3 exploration wells, in order to: 1) distinguish mud-prone vs. sand-prone deposits on seismic data; 2) understand depositional controls on stratigraphic traps within the fans; and 3) determine reservoir quality of fan sandstones. The Late Cretaceous deep-water fan system of the Foz do Amazonas basin deposited ~40 km seaward from the paleoshelf break and includes: 1) upper slope fans interpreted as sand-prone, channel-levee complexes expressed on reflection data as concave, discontinuous reflections with moderate amplitude strength; 2) basin floors fans seen as high-amplitude, continuous reflection packages (HARPs) of sand sheets with little to no structural deformation; 3) shingled turbidites expressed as offlaping reflections of moderate amplitude strength, and 4) shale packages of low-amplitude strength reflections. These large Late Cretaceous, fan complexes (~800 km2) were sourced by mature terrigenous sands eroded from hills located close to the paleo-shoreline, and deposited in conditions of: 1) ~3.19° gradient along a ~95 km-long slope; 2) strong turbidity currents; and 3) steepening of the margin as a result of rifting and passive margin subsidence. These factors combine to create conditions for good reservoir quality and trap preservation with multiple seals and traps.

TRANSPORT OF CENTRAL AMERICAN FIRE EMISSIONS TO THE U.S. GULF COAST: CLIMATOLOGICAL PATHWAYS AND IMPACTS ON OZONE AND PM2.5

WANG, Sing-Chun
Yuxuan Wang
Mark Estes
Ruixue Lei
Robert Talbot
Liye Zhu
Pei Hou

Fire emissions from Mexico and Central America are transported regularly to the U.S. Gulf Coast every spring under prevailing circulation patterns and affect U.S. air quality. Here we use a GEOS-Chem passive tracer simulation to develop the climatology of transport pathways of fire emissions over a long-term time period of April-May, 2002-2015 and estimate their adverse air quality effects for urban areas along the Gulf Coast. A conceptual model is presented to describe the transport mechanisms which involve southerly low-level jets (SLLJs) in the lower troposphere and warm conveyor belt (WCB) in the middle troposphere. The WCBs and the SLLJs explain 31% and 69% of the inter-annual variability of the mid-level and low-level events, respectively. Considering both transport and fire emissions, approximately 9% of the study period (59~88 days of 854 days) were identified as large pollution events during which Mexican and Central American fire emissions adversely impacted surface air quality at several major urban centers along the Gulf coast (Houston and Corpus Christi in TX, New Orleans in LA, Mobile in AL, and Pensacola in FL). Compared to clean maritime flow from the Gulf of Mexico, these events were estimated to result in average enhancements of maximum daily average 8-hr (MDA8) ozone and daily PM2.5 (fine particulate matter < 2.5 m in diameter) in the Gulf Coast cities of 3-12 ppbv and 2-5 g/m3, respectively.

FACIES CHARACTERIZATION USING CONVOLUTIONAL NEURAL NETWORK BY PADDING THE ORIGINAL DATASET

WEI, Zhili
Hao Hu
August Lau
Hua-wei Zhou

In this study, we build a simple convolutional neural network model (CNN) with data padding strategy and test it on the well logging dataset for rock facies classification. The well logging datasets come from the Panoma gas filed in Southwest Kansas. Study data contains five wire-line log data, two geologic properties and also the rock facies information (from the core) of each sample at a 0.5 feet interval. We choose the well 'shrimplin' as the test dataset, and treat the rest 2888 data as training dataset. The CNN model is composed of a convolutional layer with 32 filters, a max pooling layer and a fully connected layer. With our CNN model, we achieved a 90% accuracy of our test dataset.

GEOCHEMICAL CONSTRAINTS ON PACIFIC-IZANAGI RIDGE SUBDUCTION ALONG THE NE ASIAN MARGIN FROM THE MAGMATIC RECORD OF JAPAN, SIKHOTE-ALIN AND SAKHALIN

WU, Jeremy Tsung-Jui
Jonny Wu

Recent studies have debated the timing and spatial configuration of a Pacific-Izanagi spreading ridge subduction beneath the NE Asia continental margin in the Cretaceous (e.g. Maruyama et al., 1997) or early Cenozoic (Seton et al., 2015; Kimura et al., in revision; Wu et al., in prep). In contrast, other studies assert that a Pacific-Izanagi spreading ridge never reached NE Asia; instead, marginal seas existed along East Asia in the Cretaceous to early Cenozoic (Itoh et al., 2017; Domeier et al., 2017). In this study, we test these hypotheses against published and unpublished chronology and geochemical data of Cretaceous to early Cenozoic magmatic rocks from Japan, Sikhote-Alin and Sakhalin Island. We discuss their possible implications for a Pacific-Izanagi ridge subduction event, and further compare to the magmatic signature of other documented global ridge-trench interactions. In general, the Cretaceous to early Cenozoic magmatism of Sikhote-Alin and Sakhalin Island are similar to Japan in activity time and isotopic character. Our synthesis of ~400 published and unpublished age dates reveal a clear magmatic gap between 55 to 46 Ma from the Russian Far East to Japan that most closely corresponds to the early Cenozoic Pacific-Izanagi ridge subduction models. The early Cenozoic magmatic gap is supported by geochemical data that show two major differences before and after the gap: (1) Nd isotopic compositions show a sharply increase from $\varepsilon Nd = -14$ to 2 in the Cretaceous and Paleocene to $\varepsilon Nd = -2$ to 5 in the Eocene; (2) $(87Sr/86Sr)_0$ values showed a decrease after the magmatic gap. We also note that the volcanic arc shifted eastward from Sikhote-Alin and Honshu, to Sakhalin and east Hokkaido. Adakitic rocks were formed in the Sikhote-Alin and Kitakami areas. We compare our observed early Cenozoic magmatic gap and geochemical signatures to other documented ridge-trench interactions from the geological record.

BEACH AND DUNE MORPHOLOGY CHANGES INDUCED BY HURRICANE HARVEY FROM REPEAT LIDAR SURVEYS IN THE FREEPORT, TX

ZHOU, Xin
Guoquan Wang
Lin Xiong

Catastrophic event dramatically changes the morphology of the dune in its influenced scopes, such as Hurricane Harvey at 2017. Compared to the traditional surveys and recent rapid developing Airborne LiDAR measure strategy, modern mapping technique like Terrestrial Laser Scanning (TLS) combined with GPS measures the landscapes with high efficiency as well as prominent spatial and temporal resolutions. This paper compares and analyzes two sets of point clouds data acquired by RIEGL VZ-2000 before (late May, middle June) and after Harvey (early September). Lines of dune ridge, 0.6-m contour (which is the empirical value of Texas shoreline) are extracted from the bare earth Digital Elevation Models (DEMs), volume changes are calculated and multiple profiles are cut to evaluate the dynamic erosion patterns along the 7-km Bryan Beach in Freeport, TX. Operations are implemented in a novel and competent workflow with open-source tools like Generic Mapping Tools (GMT) and Geographical Resources Analysis Support System (GRASS). The primary results indicate that the beach and dune area experiences considerable topographic changes: the shoreline moves inland 3.4m averagely at the non-Brazos-delta area, situation is much serious at the delta which locates max value of advancing for 26.7m; the volume changes happened at the delta (with 2km long and 100m width) are also severe: the total volume changes from 46127m3 to 20399m3, which drops 55.8% of the original volume.

EVIDENCE FROM STRUCTURAL RECONSTRUCTION AND SUBSIDENCE FOR TWO PHASES OF TRIASSIC-JURASSIC RIFTING IN THE SOUTHEASTERN GULF OF MEXICO

ZINECKER, Marcus

Most workers now agree that the opening of the Gulf of Mexico (GOM) basin began in a southeastward direction during the Triassic and early Jurassic and affected a broad area of continental crust. Previous work has shown that Phase 1 rifts are deeply buried, rarely drilled and sampled, and poorly imaged along most GOM margins. Phase 1 rifting generated a large, post-rift sag basin, which was subsequently filled by thick evaporites. Late Jurassic, Phase 2 rifting in a more north-south direction created an arcuate area of late Jurassic oceanic crust that separated the salt into two parts (Louann to the north, Campeche to the south). In this study, I test the two-stage, bi-directional rifting model in the southeastern GOM because: 1) two sets of orthogonal rifts are known from previous mapping and are consistent with directions of both Phase 1 and 2 rifting proposed in the northern GOM; and 2) rift structure and stratigraphy in the southeastern GOM can be mapped in detail and dated from DSDP wells because the rifts are not overlain by thick salt and sedimentary rocks as in the northern GOM. Five tectonostratigraphic sequences were mapped from seismic data and wells and include: 1) early Paleozoic metamorphic and igneous basement; 2) pre-rift mid/late-Paleozoic dolomite; 3) syn-rift Jurassic arkosic sandstone, conglomerate, and shallow carbonate; 4) early Cretaceous deep and shallow water platform carbonate; and 5) late Cretaceous to Cenozoic pelagic carbonate, ooze, chalk, clay, and mud. Four seismic lines were backstripped and structurally restored using MOVE software. The result showed that total subsidence of the southeastern GOM exceeds the sum of the tectonic and sediment load subsidence; stretching factors range from 1.07 to 1.24 and are consistent with other failed rifts in continental crust worldwide. To explain the discrepancy between the total subsidence, load subsidence, and tectonic subsidence in the southeastern GOM, I propose that Phase 1 rifting is a likely mechanism because structural restorations of Phase 2 rifts show that significant Phase 1, rift-related basement relief existed prior to the Phase 2 rifts.

ELASTIC PROPERTIES OF ROCK SALT

ZONG, Jingjing
Robert R. Stewart
Nikolay Dyaur

Rock salt (or halite, NaCl) is a special type of sedimentary rock that has played a large role throughout tectonic and economic history. Rock salt's unique physical properties (ductility, low density, high velocity, flowability, and impermeability) can be critical factors in hydrocarbon traps and underground storage. However, seismic imaging and interpretation of regions with salt structures can be challenging due to salt's complex geometry and large impedance contrast with surrounding rocks. We are thus motivated to investigate the elastic properties of rock salt. To connect salt's properties and state to elastic values, we use ultrasonic laboratory measurements, well logs, and VSP data.

Poster Session

UNDERGRADUATE STUDENTS

COMPILATION OF RADIOMETRIC AGE DATES FROM THE GREAT ARC OF THE CARIBBEAN: EVIDENCE FOR AN IN SITU OR PACIFIC-DERIVED CARIBBEAN PLATE?

ALMATROOD, Mohammad

I have used GIS to compiled ~1542 radiometric dates from Cretaceous to Paleogene, island arc related rocks in the circum-Caribbean that most workers agree formed a single, continuous “Great Arc of the Caribbean". All radiometric dates are taken from the published literature that provide precise location information and radiometric parameters for three different, dating systems: Ar-Ar, Rb-Sr, and U-Pb. The goal of the compilation is to test two, differing models for Caribbean plate evolution: an in situ arc that was static between the North and South American plates - or a highly-mobile and far-traveled, Pacific-derived arc. The “Great Arc of the Caribbean” which can be followed as a semi-continuous feature from northern Colombia, along the Aves Ridge, and through the Virgin Islands, Puerto Rico, Hispaniola and Cuba. One challenge for the study is the dependence of arc ages on the amount of deformation and uplift: for example, the Hispaniola arc segment has experienced greater amounts of Neogene deformation and uplift and therefore exposes older levels of the Great Arc. For this reason, I emphasize the youngest, arc-related dates in each arc segment as a way to track the location of either the static position of the Caribbean plate (in situ plate model) or the eastward-moving Caribbean plate (Pacific-derived plate model). Ages in the 700-km-long island of Cuba show no particular directional pattern with younger Paleogene ages superimposed on areas of older Cretaceous ages. Two arc segments show good west to east younging progressions with a lateral change from Cretaceous to Paleogene arc ages and include: 1) a 300-km-long segment from Puerto Rico through the Virgin Islands; and 2) a 500-km-long segment from northern Colombia to the Lesser Antilles arc. The age progressions yield roughly the same rate of west-to-east plate motion inferred from subsidence and from plate models and therefore supports the Pacific origin of the arc.

LOWER CRUST FROM BENEATH THE ARCTIC ICE

AQIL, Diana
Jonathan E. Snow

Three major layers compose the oceanic crust: sediment, basalt, and gabbro, a total thickness normally between 5-10 km. The deepest, least accessible, and least understood of these is gabbro, a crystalline magmatic rock composed of the main minerals pyroxene, calcium plagioclase, and olivine. We studied rocks from the gabbroic layer from Gakkel Ridge, Arctic Ocean, which is the thinnest crust of the major oceans. This ocean has the slowest seafloor spreading of any mid-ocean ridge. Such ultra-slow spreading rates (<20mm/year) are accompanied by a decreased volcanic melt production in the mantle beneath the ridge. The composition of gabbro from Gakkel Ridge is affected by processes such as low pressure melt impregnation in the mantle and low degrees of mantle melting. Magma mixing is important in understanding the mantle and formation of the crust. Decompression, less pressure, and plate tectonics diverging drive partial melting. The research shows that the composition of gabbro in the Arctic Ocean will be different than the composition in the Pacific Ocean, which features a fast spreading mid ocean ridge. One difference between a fast spreading mid ocean ridge in comparison to a slow mid ocean ridge is the magma flux. In the Arctic, the magma flux is an order of magnitude less than fast spreading ridges, with no steady state magma chambers. The magma chambers here are short lived features in the crystallization process which leads to an increased range of compositions. The tectonic setting in Gakkel ridge has a subsided magmatic segmentation and topography, like a fast spreading MORB. The melt in this region is greater than other slow spreading ridges. The factors that control spreading rate are mantle temperature, mantle composition, volatiles and conduction. My hypothesis is that the composition of gabbro's in the Arctic ocean will contain different magma sources due to the thick lithosphere

LATE MIOCENE – EARLY PLEISTOCENE CLIMATE CHANGE IN THE ZHADA BASIN, SOUTHWESTERN TIBETAN PLATEAU

BALLINAS, Mario R.
Joel E. Saylor
Crystal M. Saadeh

Environmental changes in the high elevation Tibetan Plateau are variably attributed to tectonics or local or global climate change. Late Miocene - early Pliocene sedimentary deposits of the Zhada Basin exemplify this dichotomy with changes in the stable isotope composition attributed to both elevation change and long- or short-term climate change. The Zhada Basin lies just north of the Himalayan ridge crest in a region influenced by the Indian Summer Monsoon. The purpose of this study is to interpret changes in weathering regime based on the abundance of clay minerals using XRD analysis of Zhada Basin strata. We calculated the weight percent of clay phases of 57 representative samples encompassing 590 meters spanning 8.97–2.34 Ma. Lacustrine environments are dominated by detrital clay minerals and so reflect the weathering conditions in the catchment. Among the detrital clay minerals, illite and chlorite are considered primary minerals or are formed under moderate hydrolyzing conditions. Smectite and kaolinite on the other hand are generally secondary and formed under warm or extreme hydrolyzing conditions. Clay mineralogy is dominated by illite and chlorite with secondary kaolinite and smectite. The ratio of (illite + chlorite)/(smectite + kaolinite) shows three peaks. The first is occurs at 7.22 Ma second at 4.26 Ma and a third more discrete one at 3.16 Ma. Although dominated throughout by the products of physical erosion, the clay mineralogy indicates that these were periods of particularly intense physical erosion and weak chemical weathering. These peaks coincide with lithostratigraphically determined transgressive systems tracts, suggesting that transgression was not driven by increased water inflow. We propose that transgression was due to changes in tectonic subsidence or damming which decreased outflow. We also found long-term increase in the (I + C)/(S + K) ratio between the early and middle Pliocene, consistent with previous interpretations of increasing aridity during this interval.

FAULT DEVELOPMENT IN THE MADISON VALLEY: IMPLICATIONS FOR FAULT SYSTEM BEHAVIOR AND PASSAGE OF THE YELLOWSTONE HOTSPOT

CHENIN, Julian
Michael Murphy
John M. Cannon
Jonathan E. Snow

In this study, I characterize the Huckleberry Ridge Tuff fault, found in the 2.05 Ma Huckleberry Ridge Tuff (HRT hereafter) of the Madison Valley in SW Montana. The Huckleberry Ridge tuff, the oldest of the three primary ash-flow tuffs recorded within the Yellowstone Group, provides a record of the volcanic activity related to the migration of the Yellowstone hotspot. Detailed mapping of the study area showed an east-dipping, curvy planar, synthetic fault which offsets the HRT by 40 m. The fault's strike shifts from 320° to 300° from S-N within the Madison Valley. This contrasts the regional extension direction which is E-W and is accommodated by faults striking N-S, dipping at approximately 60° from each other along the Madison and Gravelly Range in SW Montana. Structural analysis of the fault, compared with regional geologic maps shows that the primary displacement zone of the HRT fault is orthogonal to the general NW-SE trend of between 280° to 300° for basin and range structures associated with the tectonic history of the region (Camp et al., 2015). Instead of following regional trends, the HRT fault appears to be part of a basin wide fault system characteristic of the Madison and neighboring valleys. In studying the deviations in the local structural trends from that of the regional tectonic history of SW Montana, I aim to gain insight into the local mechanisms related to deformation that are associated with the Madison Valley.

PETROCHRONOLOGICAL DISCRIMINATION OF WESTERN INTERIOR CAMBRIAN ZIRCONS AND IMPLICATIONS FOR ANCESTRAL ROCKY MOUNTAIN SEDIMENT PROVENANCE

HATFIELD, Kendall D.
Tyson M. Smith
Joel E. Saylor
Thomas M. Lapen

The analysis of εHf values and REE patterns of Cambrian zircons can provide a fingerprint and discriminate various sources, as well as characterize the degree of mantle versus crustal contributions of bedrock domains. Cambrian zircons within Ancestral Rocky Mountain basin strata have been variably attributed to the Appalachian orogen, the Amarillo-Wichita Uplift, or localized intrusions in CO and NM. Zircon is a durable mineral phase which is almost ubiquitous in felsic magmatic rocks and provides both petrological and petrochronological data. Due to the physical and chemical durability of zircon, it is also persistent in the sedimentary record. These features make zircon a popular target for both sediment provenance and bedrock characterization. 176Hf is produced by beta decay of 176Lu. Hf readily substitutes for Zr and is common in the crystal structure of zircon, whereas Lu is relatively rare. 176Hf/177Hf ratio increases with decreasing age of melt extraction from the mantle and with increasing crustal assimilation, this ratio provides a sensitive record of the timing of mantle extraction and post-melt crustal interaction. The research focus is on five intrusion samples from the Amarillo-Wichita Uplift in OK, the Wet Mountains in CO, and the Florida Mountains in NM: all of which are Cambrian in crystallization age and are associated with Rodinian rifting. 176Hf/177Hf ratio decreases from east to west because of increased crustal assimilation due to more poorly developed rift-related faulting and magma conduits, as well as an increase in age of assimilated crustal material. This relationship of more poorly developed rift systems and magma conduits affecting 176Hf/177Hf ratios has been demonstrated by other researchers in the Rio Grande rift. U-Pb geochronology via LA-ICPMS, indicates that magmatism spanned the late Neoproterozoic (Ediacaran)–Cambrian. Intrusions show minor differences in average age: Wet Mountains 562 ± 33.3 Ma, Florida Mountains 508.8 ± 5.8 Ma, and Amarillo-Wichita Uplift intrusions 535.4 ± 6.8 Ma (Quartz Mountain), 526 ± 21 Ma (Slick Hills), and 554 ± 10 Ma (Wichita Wildlife Refuge). The results of the experiment demonstrate the power of using petrochronological techniques to discriminate potential sediment provenance.

GRAIN-SIZE CONTROLS ON SEDIMENT PROVENANCE RECORDS USING DETRITAL ZIRCON GEOCHRONOLOGY FROM THE PUNO GROUP, SOUTHERN PERU

KARSKY, Noah J.
Joel E. Saylor
Thomas J. Lapen
Kurt E. Sundell

With increasing ease of determining U-Pb zircon ages, detrital zircon geochronology has augmented traditional petrographic techniques in reconstructions of large-scale tectonic processes. However, petrography-based provenance research indicates that the ability to reconstruct large-scale tectonic or basin processes is dependent in part on the fluvial order and is significantly influenced by grain-size in low-order fluvial systems. When applied to first-order depositional systems, heterogeneity due to sampling of small catchments may yield provenance data which does not represent large-scale tectonic or basin processes. Although well documented in petrographic data, there are no rigorous assessments of the effect of grain-size bias on detrital zircon provenance records. We present new U-Pb geochronology data from a fluvial sandstone as well as associated conglomerate clasts in order to determine if the detrital zircon composition of the sandstone matches that of the conglomerates. Samples are from the Puno Group of southern Peru which is a fluvial deposit consisting primarily of conglomerate and sandstone with secondary mudstone. The Puno Group was deposited in a retro-arc foreland basin on the border between the Peruvian Western Cordillera and Altiplano. Quantitative mixture modeling of U-Pb ages from multiple conglomerate clast types allowed comparison to the adjacent sandstone. The dominant age modes in the sandstone sample are at 34 Ma, 63-100 Ma, 149-184 Ma, 250 Ma, and 529-590 Ma. Of these, conglomerate clasts can account for the age modes at 34 Ma, 250 Ma, and 529-590 Ma. However, age modes at 63-100 Ma and 149-184 Ma remain unaccounted for. These ages are limited to the Chocolate (320–91 Ma) and Toquepala (91–45 Ma) arcs which are currently located on the western flank of the Western Cordillera. We conclude that although detritus from these arcs may have been incorporated into yet unidentified Cretaceous strata and recycled from there, a persistent drainage divide in the Cenozoic prevented incorporation of Chocolate or Toquepala arc clasts into Altiplano Basin strata. Finally, we note that there is a notable grain-size bias in the detrital zircon record, which, if identified and correctly interpreted can lead to greater insight into the details of catchment geometry and tectonic evolution.

PRELIMINARY INSIGHTS INTO THE 187OS/188OS RECORD OF THE MID-CENOMANIAN EVENT

LAUCKNER, Liam
Alan Brandon
James Eldrett
Daniel Minisini

Variations in the initial, seawater-derived 187Os/188Os (Osi) signatures of shales deposited during ocean anoxic events (OAEs) are variously interpreted as evidence for transient increases in continental weathering, and the emplacement and subsequent weathering of large igneous provinces (LIPs). When paired with other geochemical evidence, shifts toward low, unradiogenic values of Osi at the onset of OAEs suggest that vigorous LIP activity may have played a role in the triggering of OAEs. However, whether all OAEs are characterized by such Osi changes, and the temporal relationship between Osi fluctuations and the onset of OAEs, remain uncertain. To further our understanding of the relationship between Osi and OAEs, we determined the Osi chemostratigraphic profile of the Mid-Cenomanian Event (MCE), as recorded in the Eagle Ford Group (SW Texas). Unlike Ocean Anoxic Event 2 (OAE-2), which follows the MCE by ~2 Ma, the MCE has received comparatively little study. Samples used in our study come from the Iona-1 research core, which records a complete record of the Cenomanian-Turonian of the Cretaceous Western Interior Seaway. The presence of both unradiogenic (low Osi) and radiogenic (high Osi) intervals during the MCE implies the balance of the sources of osmium to seawater systematically varied throughout the event. Although Osi variations during the MCE interval appear muted compared to those of OAE-2, our data suggest that a LIP supplied unradiogenic Os to the ocean during the event. Additionally, an unusually radiogenic Osi signal at the beginning of the event is likely the result of a sudden increase in weathering of the surrounding continents.

NEW DEPOSITIONAL CHRONOLOGY AND SEDIMENT SOURCE CHARACTERIZATION FOR THE CENOZOIC MUÑANI FORMATION IN THE NORTHERN ALTIPLANO, SOUTHERN PERU

MCCAIN, Payton L.
Jeffery B. Hensley
Joel E. Saylor
Thomas J. Lapen
Gabriela Vargas-Curse
Jose Cardenas

The Cenozoic Muñani Formation of southern Peru's northern Altiplano has been proposed to have been deposited in a flexural foreland basin. Basin flexure was due to loading by crustal shortening and magmatic additions in the Western Cordillera, which bounds the Altiplano to the west. The onset of flexural subsidence is thought to be roughly synchronous along strike between ~14°–23°S based on lithostratigraphic correlations across these latitudes. Due to its location and previously assigned middle Paleocene age, the Muñani Formation is a keystone linking southern Peruvian strata to those in northern Bolivia. However, current age assignments are based on lithostratigraphic correlations only. The Muñani Formation overlies the Vilquechico Formation which has been biostratigraphically determined to range from Campanian—Maastrichtian (or possibly Paleocene, ~60Ma), suggesting a minimal, if any hiatus between the two formations. The goals of this study are to determine the maximum depositional age of the Muñani Formation, as well as the sediment sources and sediment accumulation rate. We collected paleocurrent data and detrital zircon samples in the context of an ~1000 m measured section through the Muñani Formation. The Muñani Formation is an upward coarsening succession of mudstone and sandstone meandering fluvial deposits with paleocurrents oriented chiefly to the east. Throughout, detrital zircon ages are consistent with a western source. We observe an upsection younging trend in maximum depositional ages from 46.8 ± 1.4—37.1 ± 2.7 Ma yielding a compacted sediment accumulation rate of 109.3 m/Myr. These Eocene maximum depositional ages require revision of the previously determined middle Paleocene age assignment. The revised chronology for the Muñani Formation highlights a disconformity of up to 14.6 Myr between the Vilquechico and Muñani Formations during which deposition continued in both the Peruvian and Bolivian depocenters of the Paleogene Altiplano foreland basin. This new depositional chronology indicates that the Peruvian and Bolivian depocenters only unified after the late Paleocene.

ACTA MINERALOGICA HOUSTONICA STUDENT-RUN JOURNAL

NJOKU, Stanley
Sarah Meyer
Colton Fowler
Logan French
Alvaro Iglesias
Ornella Rose
Laura Taylor
Jonathan E. Snow

With the large number of minerals that exist, there is a scarcity of mineral reviews on the lesser known minerals that form on this planet. Acta Mineralogica Houstonica is a peer-reviewed student-run journal with the purpose to research and gather information of these lesser-known or more obscure minerals. Acta Mineralogica Houstonica was started by Earth and Atmospheric Sciences department students from the 2017 UH Mineralogy course (GEOL 3370). The journal strives to bring light to the research in composition, structure, geological occurrence, and special characteristics of minerals that have been so rarely reviewed upon in depth.

A SEARCH FOR CONTROLS ON THE DISTRIBUTION OF NATURAL, SUBMARINE OIL SEEPS IN THE GULF OF MEXICO

PASCALI, Amanda

In this research, published literature is used to compile information on 94 submarine oil seeps in the Gulf of Mexico to better understand the factors that control their locations. The majority of Gulf of Mexico submarine, oil seeps are located in the US or Mexico salt provinces which were separated in late Jurassic time by the formation of an arcuate band of oceanic crust that underlies the deep Gulf of Mexico basin. Based on surveys of existing data, nearly no seeps have been identified from the shelves of either the Mexican or US Gulf of Mexico. Of the 57 natural oil seeps in the US Gulf of Mexico, 39 are found along the edges of minibasins, or sub-circular, sedimentary basins bounded on all sides by emergent, salt diapirs. Strata at the edges of minibasins are usually steeply dipping and faulted along a rotated, normal fault that forms the upper edge of the rising diapir. The steep dip of the bedding and presence of faults provides conduits for the upward rise of oil and the predominance of natural seeps in this setting. Ten seeps were identified in the flat-bottomed centers of the minibasins that are commonly underlain by strata with low dips and fewer conduits for oil to reach the surface. Eight seeps are observed in the deep Gulf of Mexico basin in areas overlying late Jurassic oceanic crust and not overlying a significant salt body. The Mexican salt body however, lacks the high level resolution bathymetric data we have for the US Gulf of Mexico, and for this reason we are not confident that minibasins play the same prominent role in the control of seeps as observed in the US Gulf of Mexico. Of the 37 seeps from the Mexican Gulf of Mexico, nine are on the shelf, ten are on the slope, and 18 are in the deep basin.

COMMUNITY FAULT MAP FOR THE CARIBBEAN PLATE

STIBBE, Emily
Paul Mann

The Caribbean plate is a small, but seismically active, plate bounded to the north and south by active strike-slip fault systems, and on the east and west by active subduction zones and volcanic arcs. While active fault maps have been produced by the US Geological Survey for certain Caribbean countries like Nicaragua and Venezuela, there is no active fault map for the entire plate. My objective is to create a GIS-based, active fault map for the entire Caribbean plate that can be made available online to the geoscience community. Using GIS, I digitized the USGS fault maps and combined these with digitized faults from a variety of sources that included published papers, regional geologic maps, and unpublished thesis studies and company reports. The map also indicates points where geomorphological or fault trenching studies have confirmed the presence of active faults. Offshore active faults were determined mainly by locating seismic lines showing that the fault ruptures the younger layers of seafloor sediment. In addition to active, plate boundary faults, I have also included active, intraplate faults - many of of which have only been recently documented. On the fault map I have plotted earthquake epicenters, representative focal mechanisms, large historic earthquakes, and GPS vectors. One of the main results of the map is to reveal the continuity and length of the active, strike-slip fault systems which is an important constraint for estimating the size of future, earthquake ruptures.

COMPARISON OF SPREADING RATE VARIATIONS IN THE SOUTH ATLANTIC OCEAN WITH SUBSIDENCE HISTORYS OF OFFSHORE WELLS AND APATITE FISSION TRACK COOLING AGES FROM THE SOUTH AMERICAN AND AFRICAN CONJUGATE MARGINS

ZAVALA, Omar

The Demerara-Guinea conjugate margin records two rift events in the breakup of Pangaea: the Triassic-Jurassic (252-201 Ma), Central Atlantic rifting event between North America and South America in a northwest-southeast direction and the Berriasian-Aptian (201-113 Ma), Equatorial Atlantic rifting event between South America and Africa. I constructed 18 burial plots from 5 wells on the Demerara margin and 13 wells from the Guinea margin to compare their rift and subsequent passive margin histories. The main tectonic events shared on both conjugate margins include: 1) Central Atlantic rift phase (give geologic age, 252 Ma to 145 Ma); 2) Central Atlantic passive margin phase (geologic age, 145 Ma to 112 Ma); 3) Equatorial Atlantic rift phase (geologic age, 112 Ma to 95 Ma); and 4) Equatorial Atlantic passive margin phase (give geologic age, 95 Ma to present day). The events occur slightly earlier by ~56 Ma on the Guinea margin than the Demerara margin. Subsidence rates of 1692.2 cm/Ma (general subsidence rate) on the Guinea margin are faster than observed rates of 236.86 cm/Ma (general subsidence rate) on the Demerara margin. These general subsidence rates are attributed to the presence of the Casamance River delta of Santonian age (86.3 Ma to Present) towards the east of the Guinea plateau.

M.S. and Early Ph.D. Students

EARTH INNER CORE ANISOTROPY AS OBSERVED BY PKIKP AND PKIIKP REFLECTED WAVES

CHEW, Jessica
Hao Hu
Yingcai Zheng

The idea of Earth inner core anisotropy is well established, and it is a very important topic in understanding the planet's core growth, magnetic dynamo, and evolution. Most data analysis techniques used to measure the anisotropy, however, use the differential traveltimes between transmitted wave pairs, which sample only shallow parts of the inner core or may be affected by mantle heterogeneities. We introduce a new method to study the effects of solely the whole inner core using a pair of reflected PKiKP and PKIIKP waves at small epicentral distances (up to about 40 degrees). We take the differential traveltime between the PKiKP and PKIIKP arrivals. This differential time measures the two-way traveltime of the P-wave, which samples both the shallow and deep parts of the inner core. This observation geometry yields a clean time window in which these phases can be identified. The small epicentral distance is key to minimizing effects of small mantle heterogeneities. Data for this project include seismograms obtained from the Incorporated Research Institutions for Seismology (IRIS) database for global earthquakes from 1990 to 2016 of moment magnitudes 6.1 – 6.5. Seismic data are loaded into a Matlab GUI program we developed from which the PKiKP – PKIIKP phase pairs can be picked at the same station. I have identified an initial set of 99 traveltime pairs from the single-trace seismograms and plotted them against latitude and longitude. No systematic change of differential time with respect to latitude can be seen, which implies an anisotropy structure that is in sharp contrast to the commonly observed polar dependence anisotropy. In order to increase the signal-to-noise ratio (SNR), I stacked signals from an array of seismometers for each earthquake. From these cleaner stacked seismograms, I found 59 traveltime pairs that suggested a different view on Earth's inner core anisotropy, which was similar to the single-trace seismogram observations.

DIFFERENTIATING SEDIMENT SOURCES DURING PALEOGENE EVOLUTION OF THE ALTIPLANO BASIN, SOUTHERN PERU

HENSLEY, Jeffrey B.
Joel E. Saylor
Thomas J. Lapen
Gabriela Vargas-Curse
P. Usnayo
Jose Cardenas
Payton L. McCain

Situated along the western margin of South America, the Andes constitute the longest (~7500 km N-S) modern ocean-continent subduction system. Between 15°S and 27°S, the central Andes is marked by the Altiplano-Puna Plateau characterized by a broad, low relief, high topography (>3.5 km) region bound on the east and west by higher topography of the Eastern and Western cordilleras, respectively. Since the Mesoproterozoic, the Andes have experienced several phases of basin formation and subsequent sediment recycling. Sediment recycling has mixed zircons with characteristic basement age groups obscuring the ability to use their presence or absence to directly fingerprint sediment sources. However, differentiating between eastern and western sources impacts orogenic models for the northern Altiplano by defining the timing and locus of crustal shortening, exhumation, and topographic growth. This study will use quantitative similarity metrics of several U-Pb geochronology age populations to discriminate eastern versus western derived sediments during deposition of the Paleogene Muñani Formation and Puno Group. Previous U-Pb geochronology studies indicate dominant sourcing from the west. However, anomalously low Cross-correlation coefficients between reconstructed and measured basin samples in the late Oligocene–Miocene may indicate the introduction of a currently undocumented source or sources. This mismatch between reconstructed and measured basin samples and the implied missing source(s) call into question the present understanding of sediment provenance within the Altiplano. We will use conglomerate clast counts and paleocurrent measurements along with non-negative matrix factorization of the measured basin samples to characterize potential sources and define their contributions to Paleogene strata. Preliminary analysis on sediment sources and paleocurrent measurements indicate a predominantly western source during Paleogene deposition. Finally, this study will highlight the ability to discriminate these recycled sedimentary sources and establish a framework for future provenance studies in the central Andes.

CHEMICAL DATA ASSIMILATION OF GEOSTATIONARY AEROSOL OPTICAL DEPTH AND PM SURFACE OBSERVATIONS ON REGIONAL AEROSOL MODELING OVER THE KOREAN PENINSULA DURING KORUS-AQ CAMPAIGN

JUNG, Jia
Yunsoo Choi
Amir Souri
Wonbae Jeon

Particle matter(PM) has played a significantly deleterious role in affecting human health and climate. Recently, continuous high concentrations of PM in Korea attracted public attention to this critical issue, and the Korea-United States Air Quality Study(KORUS-AQ) campaign in 2016 was conducted to investigate the causes. For this study, we adjusted the initial conditions in the chemical transport model(CTM) to improve its performance over Korean Peninsula during KORUS-AQ period, using the campaign data to evaluate our model performance. We used the Optimal Interpolation(OI) approach and used hourly surface air quality measurement data from the Air Quality Monitoring Station(AQMS) by NIER and the aerosol optical depth(AOD) measured by a GOCI sensor from the geostationary orbit onboard the Communication Ocean and Meteorological Satellite(COMS). The AOD at 550nm has a 6km spatial resolution and broad coverage over East Asia. After assimilating the surface air quality observation data, the model accuracy significantly improved compared to base model result (without assimilation). It reported very high correlation value (0.98) and considerably decreased mean bias. Especially, it well captured some high peaks which was underpredicted by the base model. To assimilate satellite data, we applied AOD scaling factors to quantify each specie's contribution to total PM concentration and find-mode fraction(FMF) to define vertical distribution. Finally, the improvement showed fairly good agreement.

BURIED GLACIAL GEOMORPHIC FEATURES ON SURFACES USING 3-D SEISMIC DATA IN THE SOUTHWESTERN BARENTS SEA, ARCTIC NORWAY

KONG, Janet
Julia Wellner

The Barents Sea, an epicontinental sea off of the northern coast of Norway, covers one of the world's widest continental shelves, averaging 230 meters in water depth. Over the last 3.5 million years, the growth and retreat of ice sheets grounded on the shallow continental shelf have significantly affected the bathymetry of the Barents Sea. Glacial erosion was particularly concentrated ~1.0 Ma, when multiple ice sheets converged and completely covered the Barents Sea for the first time. During this period of convergence, flowing ice eroded the substrate and carved features into the sedimentary cover, such as mega-scale glacial lineations and iceberg-keel ploughmarks. As the ice sheet retreated, new sediment was deposited over the formerly ice-covered surface, preserving the glacial features. Identification and analysis of these subsurface features, found beneath the modern-day seafloor, can illustrate past ice-sheet characteristics from before the last glacial maximum (LGM), such as paleo-ice flow direction or changes in flow patterns. This study uses interpretation of 3-D seismic grids, covering ~2000 km2, from the southwestern Barents Sea to identify glacial features on an unconformity formed during the onset of glaciation known as the Upper Regional Unconformity (URU). A series of parallel, evenly-spaced lineations ranging from 0.5-9 km long, minimum length, and trending northwest-southeast, has been identified on the URU. In comparison to previous seafloor studies, which mark the direction of ice flow from the LGM (~20 ka), these northwest-southeast oriented lineations, trending 340° - 345° on average, indicate northwest paleo-ice flow and are interpreted to form from fast-flowing ice towards Bjørnøyrenna Trough, an area of extensive former ice stream activity. The seafloor surface interpreted on 3D seismic shows evidence of iceberg scours carved by drifting icebergs following ice sheet retreat after the LGM. Iceberg scours have only been identified on the seafloor, and glacial lineations only on the URU. This study of glacial features from seafloor and subsurface will aid in examining the history of ice sheet dynamics in the southwestern Barents Sea, and comparison of these features to those in other glaciated environments can provide a better understanding of current and future ice sheet behavior.

REGIONAL COMPARISON OF DETRITAL ZIRCON POPULATIONS IN PRE-RIFT PALEOZOIC AND SYN-RIFT MESOZOIC ROCKS FROM THE GULF OF MEXICO TO NORTHERN SOUTH AMERICA

KOUASSI, Marie-Nelsy

In an effort to identify similar age populations linking tectonic blocks in the Gulf of Mexico to the Amazonian craton and evaluate existing plate reconstruction models for the pre-rift and syn-rift paleogeography, we have compiled 8,672 detrital zircon ages collected by various groups of previous workers of Paleozoic and Mesozoic ages and covering the area of rifting between southern North America, Mexico and northern South America. The dataset was first visually analyzed through the inspection of stacked probability density plots displaying the main age populations and their respective proportions. Then using the K-S Test D-values graphically represented as multi-dimensional scaling (MDS) plots, a quantitative comparison was performed. The detrital zircon age distributions of the Paleozoic strata from the Maya, Mixteca, Oaxaquia and Suwannee, initially similar to the coeval Colombian Eastern Cordillera strata as opposed to the Colorado Plateau strata in the Paleozoic time, become less similar by the Mesozoic. This initial strong affinity to the Colombian Eastern Cordillera implies that the terranes might have been derived from the same source. Thus, in a closed fit reconstruction, all of these areas may have been overlain by a common basin that covered the present-day area of the GOM, Yucatan block, and northern South America. The later dissimilarity of the target terranes' detrital zircon populations to the Colombian Eastern Cordillera and increased similarity to the Colorado Plateau in the Triassic-Jurassic time can be related to the formation and later fragmentation of Pangea which separated the peri-Gondwanan terranes from Gondwana and left them accreted to the southern margin of Laurentia.

CONVERGENCE ACCELERATION OF 2D MULTIPLE SCATTERING SERIES USING SHANKS TRANSFORMATION

LI, Xinyan
Yingcai Zheng
Hao Hu
Heather Bedle

In this research, we propose to use Shanks transformation (ST) to accelerate the convergence property of multiple scattering series in two-dimensional space. This technique provides a new way to achieve convergence in iterative seismic inversion especially in medium with large-contrast perturbations. Achieving convergence is important in seismic iteration processes, such as in the iterative full-waveform inversion (FWI). FWI uses the single scattering assumption, which assumes that the medium has weak perturbations and small-sized scatters compared to the wavelength. The weak perturbation assumption can be satisfied if the starting model is sufficiently close to the true model but this is hard to achieve in reality. Recognizing that in the majority of real models where strong heterogeneity commonly exists, we may be able to do better inversion if we use multiple scattering including the single scattering. However, it is well known that summing up multiple scattering series can be divergent. Therefore, we propose to use Shanks transformation to accelerate the series convergence in the iterative inversion process. We show forward numerical modeling to demonstrate the improved convergence property of multiple scattering series that is achieved by applying ST. In order to estimate the fidelity of Shanks transform method, the synthetic waveforms computed by Born modeling and ST will be compared with that of by Finite difference method, respectively.

HIGH-RESOLUTION REFLECTION IMAGING OF FRACTURES AROUND A WELLBORE USING CROSS-DIPOLE SHEAR SOURCE

LI, David
Xiao Tian
Hao Hu
Xiao-Ming Tang
Yingcai Zheng

High-resolution characterization of fractures near a wellbore is important for both energy production and waste storage. Here, we consider dipole-shear single-well imaging, a technique that employs acoustics logging instruments to image structures ~10's of meters away from the borehole. In a cross-dipole shear imaging survey, a tool containing multiple cross-dipole receivers and one dipole source is lowered into a well. As the tool descends into the wellbore, the cross-dipole source excite high frequency (kHz) shear waves which propagate into the formation adjacent to the wellbore. When these waves hit a scatter, they bounce back towards the well, where the downhole receivers will record them. However, the cross-dipole source also excites dispersive Stoneley and flexural waves along the surface of the borehole. Stoneley waves can be used to estimate the formation S-wave velocity around the wellbore. However, for reflection imaging, these high amplitude borehole waves are treated as noise and must be removed. In this abstract, we propose a new algorithm to image fractures around a vertical borehole. We first remove the dispersive borehole waves from the data using a non-linear signal comparison (NLSC) method. We then apply Gaussian beam migration to obtain high resolution images of fractures in the formation around the wellbore. We test our method on a field data set collected from a fractured natural gas production well and were able to image fractures 20 m away from the wellbore.

PREDICTING DAILY POLLEN CONCENTRATIONS OVER HOUSTON USING NEURAL NETWORK SYSTEMS

LOPS, Yannic
Yunsoo Choi
Ebrahim Eslami
Alqamah Sayeed

Traditional modelling systems have difficulty accurately predicting pollen concentrations. Furthermore, various stations managed by the National Allergy Bureau show conflicting predictions in pollen information. Deep-Learning Neural Networks offer great potential in pattern recognition and prediction of different pollen phenomena. They work by using a computation model inspired by the structure of neurons in the human brain. In this study, model training uses seven meteorological data sets and previous day pollen concentrations as input for the prediction. The model trains by using data from 2012 to 2016. The daily predictions are continuous from January to October 2017. The performance of the algorithm for pollen prediction was evaluated using statistical parameters by comparing daily prediction results against the observations. The algorithm was shown to achieve a high index of agreement (IOA) of up to 0.89. Random Forest algorithm was used to compute the importance of the meteorological input variables for neural network prediction. In the majority of cases, wind speed had the most influence in the prediction of pollen concentration while precipitation had the least importance in all cases. The results indicate deep-learning neural networks are able to successfully predict pollen concentrations with less processing time compared to multiple regression analyses and pollen emission models.

THE IMPACT OF REFLECTIVE IMPERVIOUS SURFACES IN THE GREATER HOUSTON AREA

MAHANEY, Kasey
Shuhab Khan

The objective of this work is to process and interpret the effects of coating impermeable surfaces in various locations around the Houston area with a reflective sealant. To accomplish this data were acquired from the LANDSAT 8 Satellite and later processed through Envi and ArcMAP. By applying thermal atmospheric correction then the Emissivity Normalization, results were obtained that demonstrated the effects of temperature from the impervious surfaces. In further research, the same process will be done over the Houston area except with higher resolution hyperspectral data and effects from the surrounding material to get more accurate results. Also determining soil moisture and impermeable surfaces to understand the extent of flooding.

ORBITAL FORCING OF LATE MIOCENE-PLEISTOCENE ENVIRONMENTAL CHANGE IN THE ZHADA BASIN, SOUTHWESTERN TIBETAN PLATEAU

SAADEH, Crystal M.
Joel E. Saylor

Orbital-scale variations in the Asian summer monsoon (ASM) during the late Quaternary are characterized by 100 kyr cycles, and have largely been attributed to the variations in ice sheet volume primarily driven by changes in Northern Hemisphere insolation. However, the Miocene-Pliocene evolution and driving mechanisms of the Indian Summer Monsoon (ISM), a subsystem of the ASM, are still not well understood. Here we present an ISM record in the late Miocene-early Pleistocene from fluvio-lacustrine sediments in the high-elevation (3.5-4.5 km) Zhada Basin, in the southwestern Tibetan Plateau. The Zhada Basin is located near the northern extent of ISM precipitation where moisture-bearing ISM air masses mix with dry westerly air masses, and so is sensitive to strengthening or weakening of the ISM. Spectral analysis reveals that variations in the Zhada Basin's $\delta^{18}O$ record are dominated by 100 kyr cyclicity throughout the late Miocene-early Pleistocene. To further study the orbital signals, we focus on our most densely sampled (1 sample/3 kyr) $\delta^{18}O$ record for the ~4.2-3.6 Ma interval, where our sampling resolution is high enough to resolve precession, obliquity, and eccentricity cycles. The $\delta^{18}O$ signal closely follows variations in eccentricity (~100 kyr) and precession (~20 kyr). On the basis of similar amplitudes, we applied a minimal tuning technique between our record and the record of daily insolation (35°N), allowing us to refine our age model. Wavelet analysis of the tuned record confirms the dominance of 100 kyr cyclicity throughout this time series, and reveals the presence of 20 kyr cycles at 3.72 and 3.84 Ma. Our record suggests that variations in daily insolation drove late Miocene-early Pleistocene high-frequency environmental changes and ISM precipitation in the southwestern Tibetan Plateau. Although 100 kyr cycles during the late Quaternary are generally considered anomalous in the marine record, they appear to have been the dominant cycle since at least the late Miocene in this high-elevation, non-marine record. We attribute the 100 kyr and 20 kyr periodicities observed in our record to represent a clipped response to summer insolation forcing, which has been shown to be largely an eccentricity-modulated precession signal.

24-HOUR OZONE PREDICTION USING ARTIFICIAL INTELLIGENCE (CNN-DNN) FOR HOUSTON

SAYEED, Alqamah
Yonsoo Choi
Ebrahim Eslami
Yannic Lops
Anirban Roy

Ozone is a criteria pollutant by photolysis of NOx and VOCs in the troposphere. Several efforts using chemical transport modeling have been unable to reproduce in-situ ozone concentrations effectively. These models also encumber significant computational resources that has necessitated use of artificial intelligence techniques such as neural networks, which present significantly improved efficiency. However, neural networks still require improvement, hence the requirement of deep neural networks to analyze the input data (typically NOx, VOCs, meteorology) in detail and identify key drivers. In this study, use of Convolutional Neural Network, a widely used deep net, was employed for the prediction of 24-hour ozone concentrations for various station in Houston. The inputs included previous 24-hour metrological condition (Precipitation, Surface Pressure, RH, Solar Radiation, Temperature, Wind direction and Wind speed), along with NOx and ozone concentrations. The accuracy achieved by the model was of 89% and the correlation with the observed data was of the order of 0.81.

IS THE TISSINT STREWN-FIELD HETEROGENEOUS? LU-HF, SM-ND AND RB-SR EVIDENCE

SUAREZ, Stephanie E.
Thomas J. Lapen
Minako Righter
Brian L. Beard
Anthony J. Irving

Tissint, the 5th witnessed Martian meteorite fall occurred on July 18, 2011 near Oued Drâa valley, east of Tata, Morocco. Currently, there is a discrepancy in crystallization age determination amongst three separate labs using combinations of Lu-Hf, Sm-Nd and Rb-Sr analyses. Each lab tested one single fragment from the entire Tissint meteorite strewn field, which included samples UWB1, ASU#1744, UNM#645. Sm-Nd analyses were performed in all three studies and produced two different dates. Analyses from two of the three studies, UH and Lawrence Livermore National Lab, are in agreement and give a date of 593 ± 25 Ma when all data are regressed. Analysis at NASA-JSC provided a date of 472 ± 36 Ma. This is approximately a 120 Ma difference in crystallization ages for separate samples analyzed from the strewn field. A hypothesis for the different ages is that the Tissint meteorite strewn field is heterogeneous and composed of launch-paired volcanic strata that fell to Earth at the same time. Tissint, along with at least 11 other depleted shergottites, have an ejection age of 1.1 Ma and exhibit a progression of crystallization ages from 347 Ma to 2403 Ma. These 11 depleted shergottites are believed to be from the same impact crater on Mars surface. The two different ages for Tissint could, in theory, represent two of these lava flows of differing ages that became intermingled during ejection. These proposed layer fragments would have launch-paired during the initial ejection and travel-paired as they fell during on observed fall. The hypothesis will be tested by isotopic investigations of several fragments from the Tissint strewn field, including the sample analyzed at JSC. Specifically, this study will analyze approximately 10 individual pieces for radiogenic isotopic compositions of Lu-Hf, Rb-Sr, Sm-Nd and trace element concentrations to confirm whether or not there are commingled materials of different age and also whether other fragments also are of different ages. These results will further assess the dynamics of launch and travel paired extraterrestrial materials.

IMAGING THE CRUSTAL STRUCTURE IN ALASKA

ZHANG, Ying
Aibing Li

Despite many geological interests in Alaska, the remote nature of much of the state has prevented a comprehensive analysis of the crustal structure in Alaska. Currently, the Earthscope Transportable Array (TA) is operating in Alaska, which significantly increases the coverage of broadband seismic station in the entire Alaska region. We propose to image the crustal structure using P-receiver functions analysis with the data collected by TA and AK networks. The H- κ method is used to estimate the mean crustal thickness and Vp/Vs ratios. From our P-receiver function results, the most distinctive crustal structures and the deepest Moho are located near the Pacific and Arctic margins. The thick crust can be seen very clearly right beneath the Alaska Range and Brooks Range, as well as in the southern Alaska where the oceanic Pacific plate is subducting under the continental North American plate. The mean crustal thickness varies from 28km to 52km in the entire Alaska of this study. The Moho depth ranges from 28km to 35km beneath the northern lowlands, while beneath the mountains it is 38-45km thick. The thickness is around 40-48km beneath the Alaska Range which is compensated by its crustal root. The transition from thick to thin crust coincides with the location of the Denali fault, a major tectonostratigraphic boundary in central Alaska, which means the crustal thickness becomes thinner from southern Alaska to central Alaska, and then turns out to be thicker from central Alaska to northern portion. For the Vp/Vs ratio map, we can see that the mean ratio is around 1.7 in the northern portion that indicates there might be more quartz-rich and felsic rocks. In the central and southern Alaska, the mean Vp/Vs ratio ranges from 1.8 to 2.1, suggesting that the rock types could be magnesium-rich or more mafic, might including more iron composition as well.

ADVANCED GRADUATE STUDENTS

BUILDING AN ANDES PLATE TECTONIC RECONSTRUCTION USING UNFOLDED SLABS FROM SEISMIC TOMOGRAPHY: IMPLICATIONS FOR FLAT SLAB TECTONICS

CHEN, Yi-Wei
Jonny Wu

Seismic tomography has increasingly provided higher resolution constraints on the position, depth, and volumes of subducted lithospheric remnants. Here we attempt to link slabs lying in the present mantle to paleo-subduction zones in Earth history using methods recently introduced by Wu et al. (2016) to structurally restore slabs back to earth surface and input them to globally consistent plate reconstructions. We provide additional constraints on pre-subduction Nazca plate paleogeography by extracting tomographic P-wave velocity perturbations within our mapped slab surfaces following Wu et al. (2016). We identified relative slow anomalies within our mapped Nazca slab that apparently show the size and position of the subducted Nazca ridge, Carnegie ridge and the hypothesized Inca plateau within the Nazca slab, which provides the most complete tomographic evidence to date to support the classic but still controversial hypothesis of subducted, relatively buoyant oceanic lithosphere features along the Andean margin.

SURFACE DEFORMATION ANALYSIS IN THE HOUSTON AREA

CRUPA, Wanda E.
Shuhab Khan

The Houston area has undergone significant ground deformation in the last century, with the main factor being attributed to groundwater/natural gas withdrawal. However, subsidence can be due to groundwater withdrawal or excess loading brought about by heavy precipitation. Houston has recently been subjected to multiple flooding events which appear to be increasing in frequency. The Houston area is also home to faults and salt domes that contribute to surface deformation. The effect that these factors have had on ground deformation has not previously been studied; certain components of ground motion have been misinterpreted, or largely ignored in scientific studies and when making policies. In this study we investigate the contributions of surface and groundwater to subsidence using data collected over the past 30 years to model/predict groundwater fluctuations, and look at the correlation with faults/salt domes and GPS data to see how surface deformation patterns have changed in recent years. Our results show salt domes moving southwards at ~10 mm/yr and upwards at ~5 mm/yr, significantly higher than previously measured. The high rate of salt motion coupled with CO_2 injection has resulted in strong uplift in southern Harris County, which acts to alleviate groundwater/gas withdrawal induced subsidence. Observed fault motion increases slightly, ~2.5 mm/yr, towards areas that have undergone a major decrease in the water level from 2006-2017. The northern Houston area shows strong subsidence up to 3.7 mm/yr and irreversible damage to the local aquifer system; both act to deteriorate the strength of the aquifer system. Post Hurricane Harvey deformation shows subsidence ranging from -68 – 5 mm, with large subsidence towards north and southwest Harris County. The weakened aquifer system in these areas is more susceptible to intense subsidence and major flooding. These trends may be matched in the Woodlands and southwest Harris County in the future.

NUMERICAL MODELING OF SEISMIC WAVE SCATTERING IN PROPPED ROCK

DANDE, Suresh

Unconventional reservoirs such as shale require hydraulic fracturing to induce fractures and create pathways to produce hydrocarbons. Hydraulic fracturing is a process of pumping a mixture of water, proppant (sand or ceramic) and few chemicals with high enough pressure to break the rock. Proppant helps to keep open the created fractures. Microseismic methods are used to estimate the stimulated reservoir volume by locating induced fractures. However, microseismic is still not able to provide accurate information about the propped volume. Propped volume is the volume of the rock that has fractures propped with proppant. Estimating accurate propped volume is important to assess the effectiveness of fracturing. In this study, we used Born approximation to model the scattered filed created by proppant in the fractures. For this experiment, we used two 3D printed models one with air-filled and second with proppant-filled fractures to see the difference in the scattered field. We used a Ricker wavelet as an input source wavelet to propagate through the medium and approximate the total field (background and scattered field) using Born approximation. The modeled total field is compared with the laboratory measured ultrasonic data.

MELTING HISTORY OF NORTHERN MARIANA TRENCH PERIDOTITE IN RESPONSE TO PACIFIC PLATE SUBDUCTION

GHOSH, Tithi
Jonathan E. Snow

Trench peridotites from Northern Mariana preserve the history of melting events occurred due to the initiation of Pacific Plate subduction beneath West Philippine Sea Plate around 52 Ma ago. The dredged peridotite samples can be broadly categorized into harzburgite and dunite. They are highly serpentinized and have spinel, olivine, orthopyroxene, and occasional interstitial clinopyroxene as major mineral phases embedded in a serpentine matrix. High Cr# and very low Ti content of spinels indicate a higher degree of partial melting experienced by these rocks. The trace element content of the spinels shows that they are devoid of any large ion lithophile elements but contain Si, V, Y, Zr, Hf in a noticeable amount. The bulk Os isotopic composition of these rocks are mostly subchondritic and resemble abyssal type peridotites. The melting pattern registered in the Re-Os and PGEs are reflective of usual abyssal peridotite type melting except a few dunites where the signature of melt-rock interaction is evident. The Re-depletion model age provides a melt depletion age of around 2.8 Ga which long predates the subduction initiation and subsequent melting of Pacific Plate. These peridotites allow an excellent window to look into the cold nose of the mantle wedge in Northern Mariana subduction zone and show the evolution of the mantle through time as a response to various melting events.

METAMORPHIC P-T-T PATHS RECORD LOWER CRUSTAL REWORKING OF THE MUZTAGHATA DOME, NORTHEASTERN PAMIR

LI, Yipeng
Alexander C. Robinson
Thomas J. Lapen
Minako Righter

Unlike the predominant upper amphibolite facies Cenozoic metamorphism in Central-South Pamir domes, the Muztaghata dome in the northeastern Pamir stands out due to its significantly higher metamorphic grade and much more variable timing of the high-grade metamorphism according to different chronometers. In order to unravel the P-T-t history of Muztaghata dome, and better constrain the timing of peak metamorphism, we applied Perple_X pseudosection and thermobarometry combined with zircon U-Pb-REE depth profiling geochronology of a mafic granulite and its surrounding garnet gneiss/amphibolite. The mafic granulite has petrographic features of retrograde eclogite, which involve white coronas of garnet porphyroblasts and oriented albite inclusions in clinopyroxene porphyroblasts. The results from the mafic granulite indicate eclogite facies peak metamorphic conditions of 800±50°C/28±5 kbar, followed by 750±50°C / 15±1 kbar high pressure granulite facies and 670±30°C/ 8±2 kbar upper amphibolite facies retrograde metamorphic conditions. Two pelitic gneisses record high-pressure granulite facies peak metamorphic conditions of 710-810°C/11-12 kbar. A Triassic orthogneiss from the eastern portion of the dome records lower P-T conditions of 580°C/8 kbar. U-Pb-REE analyses of zircon show metamorphic zircon growth from ~25-10 Ma, which we interpret to record peak and retrograde zircon growth, as well as evidence for a Late Triassic-Early Jurassic metamorphic event recorded in the metapelites. We interpret that the lithologies in the Muztaghata dome experienced two periods of metamorphism and crustal thickening, with peak metamorphism and subsequent rapid exhumation occurring during the Oligocene to Miocene. These results suggest significantly more exhumation than recorded in other Pamir gneiss domes.

IN SITU SEISMIC ANISOTROPY AROUND DEEP EARTHQUAKES IN JAPAN SUBDUCTION SLABS USING JAPAN NIED MOMENT TENSORS

LI, Jiaxuan
Yincai Zheng
Leon Thomsen
Thomas J. Lapen
Xinding Fang

It has been recognized for about 50 years that many deep earthquakes are not double-couple (DC) events. Previously we showed that in situ anisotropy around deep earthquakes could explain such observed non-DC events. Here, we adopt the same procedure to obtain anisotropy in the Pacific slab under Japan using moment tensors (MT) provided by the National Research Institute for Earth Science and Disaster Prevention (NIED). We assume deep EQs are shear dislocations embedded in TTI (tilted transversely isotropy) medium. We used the NIED moment tensors as our input data to invert for the anisotropy around deep EQs in Mariana-Japan-Kuril subduction zone. We divided the deep EQ events into 9 groups by their spatial proximity using the k-means clustering method. These 9 groups include 6 intermediate-depth groups (depth from 100 km to 300 km) and 3 deep-focus groups (depth > 300 km). Our inversion results show that the inverted TTI axes are perpendicular to the slab interface for 4 out of 6 intermediate-depth groups and parallel to the slab interface for 3 deep-focus group. The shear wave anisotropy is best resolved by our algorithm with a typical value around 26%. Our inverted anisotropy provides direct information of stress and rock fabric inside the subducting slab and may help explain the mechanisms of deep earthquakes.

TMZ/TEZ VECTOR POTENTIALS DUE TO AN ARBITRARILY ORIENTED DIPOLE IN 3-D SPACE IN THE PRESENCE OF AN INFINITE DIELECTRIC CYLINDER

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This poster outlines a new formulation for the classic electromagnetic scattering problem of a point dipole source in the presence of an infinite lossy dielectric cylinder embedded within a lossy space. The formulation is in terms of the TMz and TEz vector potential components (scalar potentials) Az and Fz for an arbitrary dipole orientation. The new solution is equivalent to the previous dyadic vector wave function solutions that solve for the electric and magnetic fields directly. Expressions for the scattered potential coefficients, for a dipole inside or outside the cylinder, can be reduced to a linear set of two equations that has a simple closed-form solution. The new potential formulation should find application in the numerical solution of various problems in electromagnetics and geophysics involving tunnels or other structures that can be modeled as cylinders.

INVESTIGATING THE INFLUENCE OF PLANETARY BOUNDARY LAYER EVOLUTION AND METEOROLOGY ON AIR QUALITY IN MEXICO CITY

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The evolution of the planetary boundary layer (PBL) is critical to air pollution studies as it impacts the concentration of pollutants in the lower troposphere. Pollutants emitted at the surface are being trapped and raised to unhealthy levels within the PBL during stable atmospheric conditions. Meteorology plays a major role, especially when a high pressure system (associated with warm, clear sky conditions) is present. This enhances the formation of ozone (O3) due to strong insolation during such atmospheric conditions. This study estimates the PBL height using a few methods such as, parcel, critical inversion, and specific humidity under different atmospheric conditions (stable, neutral, and convective) based on the potential temperature (ɵ), and specific humidity (q) profiles measured continuously by a MP-3000A microwave radiometer and wind speed and direction data up to 3-5 km (a.g.l) by a 915 MHz RAPTOR radar wind profiler during two weeks in March 2016 from a monitoring site in Mexico City. Mexico City is located in a basin, which prevents proper ventilation of the polluted air. Synoptic weather maps were provided by CONAGUA Servicio Meteorológico Nacional for the pollution episode (March, 2016). The hourly average concentration of the pollutants (Ozone and CO) were provided by the SEDEMA (Secretaría del Medio Ambiente), the Environment Department of the Mexico City Municipality. The peak O3 concentration of ~ 188 ppb observed on 14 March, 2016 (and even higher at some other stations) were the highest since 2007 and thus presented the most severe smog episode for almost a decade. The peak pollutant concentrations correlate well with the meteorological observations (weak winds, stable PBL) as well as air masses circulation within the Mexico basin.

INTEGRATED HYPERSPECTRAL AND GEOCHEMICAL STUDY OF SEDIMENT-HOSTED DISSEMINATED GOLD AT GOLDSTRIKE DISTRICT, UTAH

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The Goldstrike district in southwest Utah is believed to be similar to Carlin-type gold deposits in Nevada that are characterized by sediment-hosted disseminated gold. Optimum structural and stratigraphic conditions facilitated precipitation of gold in arsenic pyrite grains from ascending gold-bearing fluids. This study used ground-based hyperspectral imaging to study a core drilled in the Goldstrike district covering basal Claron Formation and Callville Limestone. Spectral modeling of absorptions at 2.34 and 2.2 μm allowed the extraction of calcite and clay mineral abundances and identification of lithology. Integrating with fire assay metallurgy and ICP-MS geochemistry data, this study identified optimum stratigraphic relation in basal Claron Formation, as well as decarbonation and argillization in Callville Limestone that are related with gold mineralization. This study shows an example of utilizing ground-based hyperspectral imaging in geological characterization, which can be broadly applied in determination of mining interests and classification of ore grades. The utilization of this new terrestrial remote sensing technique has great potential in resource exploration and exploitation.

HURRICANE HARVEY INDUCED MORPHOLOGICAL CHANGES AND SEDIMENTATION PATTERNS IN BOLIVAR ROADS

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Hurricane Harvey was the first major hurricane (Cat 4) to make landfall in the United States since Wilma in 2005. After making landfall, the storm stalled over the coast of southeastern Texas for four days, bringing catastrophic rainfall which resulted in major flooding. An estimated 34 trillion gallons of freshwater fell over the Texas-Louisiana coast. Large volumes of sediment were mobilized by the flooding in the Houston and surrounding regions which were transported by the rivers and bayous and dumped into the Galveston Bay. Strong currents might have further transported the sediments into the Gulf of Mexico through the three tidal inlets of Galveston Bay – Bolivar roads, San Luis pass and Rollover pass. The goal of this study is to understand extreme storm sedimentation patterns and geomorphological changes that occurred in the Bolivar roads due to Hurricane Harvey. High resolution multibeam, side-scan sonar and chirp sonar data were collected in Bolivar roads in the weeks before Hurricane Harvey. A second survey was conducted three months later to document post-Harvey conditions. In this study, we compare the two data sets. A multibeam sonar measures the depth of the ocean and will be used to generate a high-resolution bathymetric map of the seafloor. This map will be useful in identifying various bedform features in Bolivar roads like dunes, ripples, ridges, and to understand how these features changed post-Harvey. A side-scan sonar sends out sound beams and records the intensity of the return and paints a picture of the seafloor. This intensity map contains information on the hardness and texture type of the sediment. These data will help in classifying the seafloor into various sediment types in Bolivar roads. A chirp sonar generates a two-dimensional stratigraphic section of the seafloor by sending an acoustic pulse and recording various returns from the seafloor. The chirp sonar pulse interacts with the seafloor and subsurface and provides a two-dimensional cross-section of shallow sediments. This stratigraphic section will be useful in identifying and characterizing the thickness and layering in the sediment cover in Bolivar roads.

EVALUATION OF A DIRECT GEOREFERENCING TLS SURVEY METHOD FOR BEACH AND DUNE MAPPING: A CASE STUDY AT FREEPORT, TEXAS

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TLS has been frequently applied for large-scale beach and dune mapping projects for the purposes of coastal erosion study and coastal management. Acquiring 3D point clouds involves scanning multiple scenes from different directions to minimize the shadow issues. Registration of point clouds is a fundamental issue in TLS remote sensing. In order to transform the registered point clouds into a global coordinate system, several GPS units are often needed to measure local positions of at least three reflectors. As a result, TLS surveying projects often involve a lot of manpower because it is very time consuming to setup, move and adjust reflectors in the field. This paper develops a rapid TLS surveying method that directly georeferences point clouds from individual scans to a global coordinate system. Only one scanner, one reflector and two GPS units are needed in the field. This method uses onboard inclination sensors installed on modern laser scanners and two GPS units to precisely decide the position and orientation of the laser source, in turn, the 3D positions of point clouds. Direct georeferencing TLS surveying method was applied to map a 7-km long and 500-m wide beach and dune area in Freeport, Texas in 2017. Conventional TLS surveying methods was applied in a 1000-m long and 500-m wide area for comparison. Bare earth DEMs derived from these two methods are compared in this study. The RMS of the differences of these two DEMs (0.3 m by 0.3 m) is 5.0 cm. The accuracy of the bare-earth DEM derived from the direct georeferencing method is further evaluated with a DEM derived from dense GPS measurements within a 1500m by 50m beach area. The RMS of differences of the two DEMs is approximately 9.0 cm. This study indicates that the direct georeferencing survey method is able to achieve almost the same accuracy as the conventional TLS survey method with much less field and post-processing efforts. The direct georeferencing TLS surveying method can be applied to other areas that have open sky views for GPS to make a centimeter level accuracy positioning within a half hour observation period.