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Faculty advisor for Student Research Day – Dr. Regina Capuano is an Associate Professor of Geosciences at the University of Houston. She completed her PhD in Geology at the University of Arizona in 1988.

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Proma Bhattacharyya was first introduced to geology during her B.S. She finished her undergraduate degree in India and then came to the US to pursue higher education. She got a M.S. in geology from the University of New Mexico. During her M.S., she studied the Satellite Imagery Evaluation of Soil Moisture Variability in the Ganges Basin in India. After that she moved to the University of Houston for her Ph.D. Currently she is looking into point bar and associated geomorphic elements in ancient as well as in recent settings with Ground Penetrating Radar (GPR) and Airborne Light Detection and Ranging (LiDAR).

Atif Hariz received his B.S degree in Geology from the American University of Beirut in 2008. He is currently pursuing his Master's Degree in Geology at the University of Houston. His thesis includes the study and identification of hurricane washovers in South Texas and overseen by his advisor Dr. Donald Van Nieuwenhuise. Participated in the 2015 Imperial Barrel Award Program (IBA) "an annual prospective basin evaluation competition" by the AAPG. He also works part-time as an environmental geologist while working on his degree.

Pin Lin is a PhD student in Geology with Dr. Paul Mann in the University of Houston. She received a MS in Geology and Geophysics from Missouri University of Science and Technology in May 2015, after graduating with her MS in Geological Engineering from China University of Petroleum in May 2013. Her master's thesis focused on seismic facies interpretation from a gas field in the Bahai Basin of China. Her PhD study with CBTH is using well, seismic reflection and gravity data to examine the V-shaped area of Jurassic oceanic crust in the southeastern Gulf of Mexico and the rifted continental area surrounding the area of oceanic crust.

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Oral Presentations

COMPARISON OF AEROSOL LIDAR RETRIEVAL METHODS FOR BOUNDARY LAYER HEIGHTS

VANESSA CAICEDO, BERNHARD RAPPENGLUECK, BARRY LEFER

The boundary layer (BL) is defined as the lowest layer in the atmosphere directly influenced by the earth's surface therefore giving it a complex diurnal evolution. Convection and turbulence created by surface heating begins the gradual growth of the BL at sunrise and eventually its decay after sunset. This layer is of vital importance since its daily evolution determines the extent of vertical mixing of gaseous compounds and particles that affect our health and environment. The BL is also an essential parameter used for accurate forecasting of both weather and climate models and ground based measurements. For this reason, continuous measurements of boundary layer height (BLH) are vital however; a continuous monitoring of the BL is rarely available. This study uses ceilometers to measured aerosol backscatter in order to calculate BLHs uninterruptedly. In order to evaluate the retrieval of BLHs from aerosol LIDARS, we test two distinct methods based on two assumptions: 1) the BL contains constant concentration of aerosols therefore a constant concentration of backscatter due to convective and turbulent mixing and 2) the clean free troposphere (FT) above will create a negative gradient in backscatter from higher concentrations within the BL towards lower concentrations in the FT. The local maximum of this gradient is identified as the top of the BL. This local maximum also correlates with a variance local maximum since the entrainment zone between BL and FT contains high aerosol variability due to clean air masses from the FT mixing with turbid masses from the BL. The data used is from a Vaisala CL31 ceilometer located at the University of Houston Main Campus. BLHs from this ceilometer are determined using an aerosol backscatter gradient method and a cluster analysis method using aerosol backscatter profiles' variance. These are validated with radiosonde and aircraft derived BLHs. The goal of this study is to present and discuss the advantages and drawbacks from the two methods used.

INTEGRATED AIR QUALITY MODEL STUDY WITH FOCUS ON HEALTH AND COST IMPACTS

EBRAHIM ESLAMI

The health and cost impact of biomass burning events over United State is studied using combined air quality and health impact modeling. Effective assessment of health and cost effects from air pollution associated with wildfire events is critical for supporting sustainable management and policy analysis to reduce environmental damages. In this study, air quality scenarios containing biomass burning events were conducted using the Community Multiscale Air Quality (CMAQ) modeling system of the U.S. Environmental Protection Agency (EPA) for 2012 and 2013 with a spatial resolution of 12km x 12km. The U.S. EPA GIS-based computer program, Environmental Benefits Mapping and Analysis Program - Community Edition (BenMAP-CE) was employed to address an inclusive figure of health and cost impact caused by changing ambient ozone and PM2.5 concentrations influenced by the fire events. The basis of BenMAP-CE is the use of a damage-function approach to estimate the health impact of an applied change in air quality by comparing a control scenario (the one that includes wildfire events) with a baseline scenario. The major factors influencing such an approach are population, exposure to the pollutants, adverse health effects of a specific pollutant, and economic costs. This study also examines how biomass burning across U.S. influences people's health in different months and seasons and how much wildfire events cost during these periods of time. Since biomass burning events resulted in higher ozone and PM2.5 concentration values in urban regions, the results indicate that wildfire events cause a considerable increase in incident estimates and costs. This study demonstrates that BenMAP-CE can be successfully utilized as a proper tool to obtain health and cost impact of biomass burning events.

OZONE PHOTOCHEMISTRY TRENDS IN THE HOUSTON SHIP CHANNEL

LAURA MARGARET JUDD, JAMES FLYNN, BARRY LEFER, MARK ESTES, DAVID WESTENBARGER

Due to transportation and industry dominating Houston's economy, local air quality is in non-compliance according to EPA NAAQS for ozone. Policy-makers and industries have worked together to decrease the reactive hydrocarbon and NOx emissions in order to bring the area into attainment of the ozone NAAQS. The number and severity of ozone events have decreased over time due to decreases in ozone precursors emissions. This study examines these changes in the photochemical environment in the Houston Ship Channel since 2000, where the combination of combustion processes and hydrocarbon emissions still cause high ozone events. Hydrocarbon, trace gas, and meteorology data were input into the Langley Research Center (LaRC) photochemical box model to study trends in photochemistry since the turn of the century. Emphasis is given on ozone formation mechanisms and efficiency, speciated hydrocarbon reactivity, NOx/VOC sensitivity and how these parameters vary diurnally and annually. The measurement sites in this study are spread through the borders of the Houston Ship Channel, with Clinton Drive in the west, Deer Park in the south, and Channelview to the north. The Ship Channel is shown to be largely VOC sensitive with respect to ozone production. Decreases in HRVOCs are the primary reason for fewer ozone exceedances, the transition to a more VOC sensitive regime, and decreases in instantaneous ozone production efficiency. To bring Houston metropolitan area into compliance with ozone NAAQS, these results suggest further regulations on industrial and mobile HRVOC emissions in Houston.

IMPACT OF SYNOPTIC SCALE FEATURES ON THE YEAR-TO-YEAR VARIABILITY OF OZONE EXCEEDANCES IN SOUTHEAST TEXAS

ALEXANDER KOTSAKIS, JAMES H. FLYNN, AMIR SOURI, MATTHEW ERICKSON, GARY MORRIS, MARK ESTES, DAVID WESTENBARGER

Meteorological conditions for high ozone events require sunlight, clear skies, and stagnation. Although reduced emissions have decreased the number of ozone exceedance days in Houston in the past decade, there is still year-to-year variability. This variability can't be explained solely by drastic changes in emissions, but rather by year-to-year variability in large-scale meteorological patterns. This study identifies potential synoptic scale meteorological features that influence severity of each ozone season. The peak daily 8-hour ozone will be determined for each day of the specified time period and will be correlated with meteorological variables including temperature, mean sea level pressure, and solar radiation with an emphasis on how synoptic-scale patterns are influencing these correlations. This will build on previous work that specifically looked at how emissions reductions along with changes in certain meteorological wind patterns, helped decrease the amount of ozone exceedances in Houston, TX.

EMISSION ESTIMATES OF TRACE GASES AND VOLATILE ORGANIC COMPOUNDS FROM A CONTROLLED GRASSLAND FIRE EXPERIMENT

LEI LIU, XIN LAN, BARKLEY SIVE, BARRY LEFER, JAMES FLYNN

In January 30, 2013, a control burn experiment was conducted by the Texas Forest Service, in which ~ 4047 m2 of a grass field was burned. Our mobile lab was set at the downwind boarder of the burn and took data before, during and after the burn. The THg CO, CO2, CH4, and NO data measured by mobile laboratory can provide important information on fresh biomass burning emissions. Volatile organic compounds were also measured at the control burn period. Sixteen whole air samples were taken in ~30 min period at the same location as the mobile lab. Biomass burning is a major source of the methyl chloride (CH3Cl), methyl bromide (CH3Br), and a minor source of methyl iodide (CH3I), which potentially delivers halogens to the stratosphere and causes ozone depletion. I will calculate the emission ratio of some VOCs species over CO, which I believe can provide important information on VOCs emissions from biomass burning.

A 15-YEAR CLIMATOLOGY OF WIND PATTERN IMPACTS ON SURFACE OZONE IN HOUSTON, TEXAS

AMIR HOSSEIN SOURI, XIANGSHANG LI, ALEXANDER KOTSAKIS, XUN JIANG

Houston is recognized for its large petrochemical industrial facilities providing abundant radicals for tropospheric ozone formation. Fortunately, maximum daily 8-h average (MDA8) surface ozone concentrations have declined in Houston (− 0.6 ± 0.3 ppbv yr− 1) during the summers (i.e., May to September) of 2000 to 2014, possibly due to the reductions in precursor emissions by effective control policies. However, it is also possible that changes in meteorological variables have affected ozone concentrations. This study focused on the impact of long-term wind patterns which have the highest impact on ozone in Houston. The analysis of long-term wind patterns can benefit surface ozone studies by 1) providing wind patterns that distinctly changed ozone levels, 2) investigating the frequency of patterns and the respective changes and 3) estimating ozone trends in specific wind patterns that local emissions are mostly involved, thus separating emissions impacts from meteorology to some extent. To this end, the 900-hPa flow patterns in summers of 2000 to 2014 were clustered in seven classes (C1–C7) by deploying an unsupervised partitioning method. We confirm the characteristics of the clusters from a backward trajectory analysis, monitoring networks, and a regional chemical transport model simulation. The results indicate that Houston has experienced a statistically significant downward trend (− 0.6 ± 0.4 day yr− 1) of the cluster of weak easterly and northeasterly days (C4), when the highest fraction of ozone exceedances (MDA8 > 70 ppbv) occurred. This suggests that the reduction in ozone precursors was not the sole reason for the decrease in ozone exceedance days (− 1.5 ± 0.6 day yr− 1). Further, to examine the efficiency of control policies intended to reduce the amount of ozone, we estimated the trend of MDA8 ozone in C4 and C5 (weak winds) days when local emissions are primarily responsible for high ambient ozone levels. Both C4 and C5 show a large reduction in the 95th percentile and summertime trends mainly due to effective control strategies. Based on the 5th percentile daytime ozone for C1 (strong southeasterly wind) in coastal sites, this study found that the cleanest air masses that Houston received became more polluted during the summer of 2000–2014 by 1–3 ppbv. Though this study focused on Houston, the analysis method presented could generally be used to estimate ozone trends in other regions where surface ozone is dominantly influenced by both wind patterns and local emissions.

A COMPARISON OF NEW UPSCALING METHODS DERIVED FROM THE SIMPLE AVERAGING METHOD WITH THE BACKUS AVERAGING METHOD

EZZEDEEN ALFATAIERGE, YULIYA GORB, EVGENI CHESNOKOV

Upscaling is an essential tool in microseismic studies, as it bridges the gap between the high-resolution well log measurements and low-resolution seismic observations. Various upscaling methods have been published and discussed, such as the Simple Averaging Method (SAM) and the Backus Averaging method (BAM). These methods use a windowed averaging approach that corresponds to an arithmetic mean in the SAM. Therefore, new upscaling methods are proposed by accommodating different mean calculations. We introduce the simple harmonic-, simple geometric-, and simple quadratic upscaling methods as a derivation from the Simple Averaging method, using the different power mean calculations. Various well log data are used to compare the effectiveness of these methods in comparison to upscaling using the SAM and BAM. In conclusion, from a mathematical perspective averaging a given set of values using the various power means yields different results. The results however obey a hierarchy where the harmonic average is less than or equal to the geometric, the geometric is less than or equal to the arithmetic, and the arithmetic is less than or equal to the quadratic average. The results of the new upscaling methods on a given well from the Gulf of Mexico show that the data obeys the averaging hierarchy, however the difference between the results was very minimal that it can be considered to fall within a margin of error. The most important finding is that the results of the simple harmonic method are the BAM. Although the new upscaling methods are derived from mathematical theology, and they don't consider the physical characteristics of the medium, the use of the harmonic mean in averaging across a VTI media holds higher validity to the use of the arithmetic mean from both a geophysical and mathematical perspective.

TECTONIC DRIVERS OF THE WRANGELL BLOCK FOREARC SLIVER: INSIGHTS FROM 3D GEODYNAMIC

KIRSTIE L. HAYNIE AND MARGARETE A. JADAMEC

Intra-continental shear zones are associated with numerous plate boundaries and may play a key role in understanding the mechanics of plate boundary deformation and how the plate convergence is manifested in the upper plate in regions of oblique convergence. In particular, shear zones can facilitate the development of as well as modulate the motion of forearc slivers. However, the relative role of underlying subducting plate in driving the forearc sliver motion and the resisting force from within the shear zone to the motion of the forearc sliver is not well understood. Here we present high-resolution three-dimensional geodynamic models of flat slab subduction in Alaska that vary the (a) strength of the Denali fault represented as a major intra-continental shear zone and (b) coupling between the subducting plate and overriding plate. Models with a higher plate boundary viscosity (10^21 Pa s) and lower Denali fault viscosity (10^17 Pas) result in the fastest motion of the Wrangell block (10 mm/yr in the northern Wrangell block and faster close to the trench). Here the increased tractions along the plate interface drive the overlying Wrangell block northwestward, such that it moves semi-independent of the North American plate. The models show that the ability of the slab to drive forearc sliver motion in the overlying plate depends to a first order on the intra-continental shear zone strength. A weak intra-continental shear zone decouples the forearc sliver from the remainder of the overriding plate, thus providing less resistance to the driving force of the slab. The calculated fault parallel offset suggests tractions along the flat slab in Alaska contribute ~35%of the strike-slip motion along the Denali fault determined from GPS and ~25% of the observed long-term strike-slip rates on the Denali fault. In addition, the models produce a band of high strain rate and weakened upper plate, above where the flat slab steepens westward in the subsurface, which correlates with observed shallow seismicity in the upper plate and may indicate the western edge/diffuse zone of the Wrangell block forearc sliver.

VELOCITY DISPERSION AND ATTENUATION OF A WAVE PROPAGATING IN A FRACTURED MEDIA

ANNA KRYLOVA, GENNADY GOLOSHUBIN

Was considered an effect and properties of slow and dispersive Krauklis wave within individual fractures propagating through the fractured fluid saturated media. The averaging of the elastic properties of the fluid filled fractured rock was discussed for different (exponential, power, fractal, and gamma) laws of the fracture distribution with the consideration that propagation of Krauklis wave is present. The appearance of such wave tends to increase P-wave velocity dispersion and attenuation with the decrease of frequency. The comparison of fractal laws with different fracture densities shows greater velocity dispersion and attenuation for larger fracture density, in particular at low seismic frequencies. The results exhibit remarkable difference of the frequency and angular dependency of the P-wave reflection coefficients from the fractured layer in comparison with homogeneous layer, that could be a clue to the exploration and control of the naturally fractured reservoirs (gas/oil shale fields) or monitoring regions of the induced hydraulic fracturing with the seismic waves.

IN SITU SEISMIC ANISOTROPY IN THE VICINITY OF GLOBAL DEEP EARTHQUAKES

JIAXUAN LI, YINGCAI ZHENG, LEON THOMSEN

Standard seismological methods using the shear wave splitting and travel times usually obtain an averaged anisotropy along the seismic ray path. We use earthquake wave radiation patterns to invert for the in situ anisotropy in the focal regions of deep earthquakes. Our inversion method is based on the explicit relationship between the equivalent force couples (moment tensors) and the anisotropy. We validated our methodology using forward modeling. We applied this method to Tonga, Mariana, Japan, Kuriles, South America and Java subduction zones. We found that a TTI model with symmetry axes perpendicular to the subducting slab interfaces can explain the non-double components in the moment tensors for nearly all earthquakes of different depths. This information provides new constraints on rock physics and mechanics on slab-mantle interactions and processes.

SEISMIC CHARACTERS OF PORE PRESSURE DUE TO SMECTITE-TO-ILLITE TRANSITION

XUAN QIN AND DE-HUA HAN, UNIVERSITY OF HOUSTON

In this study, we strive to understand unloading overpressure caused by smectite-to-illite by using shelf well log data from offshore Louisiana. Two trends of smectite-to-illite transition can be categorized, based on their signatures on the sonic travel time and density crossplot. It corresponds to the cases of fluid expansion and fluid escape during the smectite-to-illite. The fluid expansion can arise high magnitude overpressure and tends to happen when the upper formation has been undercompacted and has less sand content (approximately 12% in average). For the fluid escape case, it has relative deeper overpressure onsets and its overlying formation is less undercompacted and has more sand content (approximately 55% in average). From the synthetic seismic gathers, the two trends of smectite-to-illite have different seismic responses, and can be discerned with AVO technique.

THERMAL HISTORY AND PROVENANCES OF DRUMMOND BASIN, QUEENSLAND (AUSTRALIA) FROM U/PB AND (U-TH)/HE DATA

WENYUAN ZHANG, KYOUNGWON MIN, SCOTT BRYAN

Drummond Basin is a major Late Devonian-Early Carboniferous rift basin in eastern Australia. To investigate its thermal history and provenance, we applied single-grain (U-Th)/He, in-situ U/Pb and He-Pb double dating techniques to detrital apatite and zircon grains. Inverse modeling of detrital zircon U/Pb ages indicates that the major age groups are 412 Ma and 465 Ma. The southwestern Thomson basement, Anakie Province and Charters Towers Province are suggested to be the potential sources of the detrital zircons in the Drummond Basin, because these units contain zircons with U/Pb ages comparable to the two major age components.

DOOR POINT: CRETACEOUS VOLCANISM IN THE GULF OF MEXICO

PETER ANDERSON

The Door Point structure penetrated by the Shell Oil S.L. 3956 well no. 1, located offshore in St. Bernard Parish Louisiana represents the singular observed subsurface occurrence of igneous rock in the entire offshore region of the GoM that is Cretaceous in age. Identified in the literature as a volcano, sill or other primary intrusive/extrusive feature, with an age of 82 ± 8 Mya, the Door Point "Volcano," has received very little study since its discovery in the 1970's. Preliminary study of the core shows that the unit consists of volcaniclastic rocks. Initial review of the geophysical logs provided by Shell Oil and Drilling Info show an apparent offset in the resistivity, with a maligned or absent deflection of the Spontaneous Potential curve. The sequence of volcanics extend vertically a minimum of 396m with no base identified, and the singular cored interval taken of the final 8.5m. Initial petrographic examination has revealed there to be both massive un-bedded polymictic agglomerates as well as bedded volcanic ash. The basalt cobble agglomerates sequentially alternate with the packages of finer grained volcanic ash. Grain size for the igneous cobbles within the agglomerates range in diametric extremes from a maximum of 5 cm to a minimum of 1 – 2 cm. Sedimentary structures are absent in the coarser sequences, but are exhibited in the volcanic ash beds, in the form of cross bedding. The clast populations vary in composition from fragments of sedimentary rock, to the igneous rocks of interest. Possessing a porphyritic texture and angular in appearance the clasts contain visible clinopyroxene phenocrysts, in an aphanitic groundmass; CI > 90. These results suggest the cobbles are sourced from multiple volcanic centers, and have undergone a multistage cooling history. Coupled with the presence of the calcite cement, the cross bedding is indicative of a marine or fluvial depositional system. We are able to reconstruct a regional story of episodic volcanism in the nascent Gulf of Mexico Rift during the late Cretaceous.

DISCRIMINATING SEDIMENT SUPPLY VERSUS ACCOMMODATION CONTROLS ON LATE CRETACEOUS FORELAND BASIN STRATIGRAPHIC ARCHITECTURE IN THE BOOK CLIFFS, UTAH USING DETRITAL ZIRCON DOUBLE DATING

NICOLAS BARTSCHI, THOMAS J LAPEN, PETER COPELAND, ROSS ANDREA

Middle to late Campanian strata of the Book Cliffs, Utah record the Late Cretaceous deposition of three clastic wedges in the North American Cordilleran foreland basin east of the Sevier thrust belt. Variations in wedge geometries provide an opportunity to evaluate the effects of sediment supply versus accommodation on foreland basin stratal architecture. There is a significant increase in eastward progradation rate from the Lower to the Upper Castlegate Sandstone. However, the progradation rate decreases in the overlying Bluecastle and Price River formations, as well as the laterally equivalent Farrer and Tuscher formations. Rapid progradation during Upper Castlegate deposition may be caused by increased sediment supply from either rapid exhumation of the Sevier thrust-belt or introduction of a new sediment source. Alternatively, reduced accommodation within the proximal foreland basin from uplifts associated with Laramide deformation, or a transition from flexural to dynamic subsidence, could produce the same observed rapid wedge progradation. We identify changes in sediment provenance and source-area exhumation rate using a combination of detrital zircon U-Pb dating and (U-Th)/He dating. Detrital zircon U-Pb data reveals a significant shift in provenance between all wedge boundaries. Quantitative comparisons between new and published detrital zircon U-Pb provenance data indicates an overall upsection decrease in thrust-belt-sourced Mesozoic eolianite and North American passive-margin source areas coupled with an increase in a southern magmatic arc and Mogollon Highland source area. Detrital zircon (U-Th)/He data shows a significant upsection decrease in lag time between the Lower and Upper Castlegate. Near-zero lag times during the Upper Castlegate is consistent with rapid exhumation attributed to accelerated thrusting of the Sevier thrust-belt. Conversely, there is no change in lag time between the Upper Castlegate and overlying Price River Formation, suggesting steady exhumation of the Sevier thrust-belt with no significant changes to thrusting. Rapid progradation during the Upper Castlegate can be attributed to an increase in sediment supply due to both rapid exhumation of the Sevier thrust-belt and an introduction of a new sediment source. However, the data do not rule out the potential additional influence of reduced accommodation associated with early Laramide deformation during Upper Castlegate deposition.

MODELING OF RARE EARTH ELEMENT ZONATION IN HIGH PRESSURE/LOW TEMPERATURE (HP/LT) GARNET FROM THE MOTAGUA FAULT ZONE IN CENTRAL GUATEMALA.

DEBORAH BRADLEY, TOM LAPEN

Trace element concentration profiles measured across garnet porphyroblasts in a sample of high pressure/low temperature (HP/LT) lawsonite eclogite from south of the Motagua Fault Zone in central Guatemala reveal high heavy rare earth element (HREE) concentrations in garnet cores and a second increase in concentration at their rim. In contrast, major element compositions (Fe, Mg, and Ca) across these same garnet grains record typical prograde bell-shaped zonations from the core to halfway to the rim. Rimward of this, the Mn zonation deviates from the typical prograde zonation of decreasing concentrations toward the rim and steadily increases in concentration. This is followed by an abrupt decrease in Mn concentrations approximately 100 µm from the rim. Pyrope, almandine, and grossular components (Mg, Fe, and Ca, respectively) also show marked compositional change 100 µm from the rim. This chemical zonation has been observed previously in other samples from the region south of the Motagua Fault, but has not been adequately explained.

LATE PALEOZOIC TO MESOZOIC TECTONIC EVOLUTION OF XAINZA AREA IN THE NORTH OF LHASA TERRANE, TIBET: CONSTRAINTS FROM FIELD OBSERVATION, PETROGRAPHIC ANALYSIS, AND ZIRCON U-PB GEOCHRONOLOGY

SUOYA FAN, LIN DING, AN YIN

The geological and geochronologic investigation of Xainza area covering the middle segment of Shiquanhe-Namuco mélange zone (SNMZ) provides some new perspectives for some issues previous to Cenozoic. The U-Pb age data of detrital zircons from Permian Angjie Formation shows its affinity with the Qiangtang and Himalaya area, indicating that Lhasa terrane was separated from the northern margin of Indian plate, rather than from Western Australia as some researchers proposed. Late Triassic Duoiburi Formation is limitedly distributed west of the Mujiu Co. The detrital zircon age data shows it lacks the zircon younger than 450 Ma, which is a distinct difference from contemporary sediment in Qiangtang and south part of Lhasa terrane. The distribution of ages older than 450 Ma correlates well with the data of Paleozoic sequence in the near area, which might be the main provenance. One gabbro sample from the Yongzhu ophiolite within the SNMZ yielded a weighted mean age of 153 Ma. The ophiolite is overlaid by Late Jurassic – Early Cretaceous Rila Formation. Yongzhu ophiolite, along with other ophiolites within SNMZ, might represent an in situ Late Jurassic-Early Cretaceous suture within the Lhasa terrane, other than klippes rooted in the Bangong-Nujiang suture. The north directed thrust faults in the SNMZ juxtaposed the Paleozoic strata and ophiolite onto the Cretaceous basin, and geochronologic data implies that the provenance of Early Cretaceous Duoni Formation in the basin is mainly the Early Cretaceous igneous rocks at the north of Lhasa terrane and the Paleozoic strata in the hanging wall. Combining with other geologic observation and previous thermochronologic study in the near area, we propose that this fault zone initiated at Early Cretaceous and controlled the exhumation of the Paleozoic sequence and Early Cretaceous basin fill in the footwall. Its initiation is earlier than the mainly south-directed thrusts in the BNS and the retro-arc thrust at the south part of Lhasa terrane. The extensive igneous activities at the north part of the Lhasa terrane in Early Cretaceous, including the 6 dated samples (105-120 Ma) in this study, might be caused by the suturing of oceanic basins between Northern and Central Lhasa.

INDICATION OF HETEROGENEOUS MELT DEPLETION BENEATH NORTHERN MARIANA ARC

TITHI GHOSH, JONATHAN E. SNOW

The Izu-Bonin-Mariana arc (IBM), off the coast of Japan, represents the largest intra-oceanic subduction zone where the Pacific plate is being subducted below the Philippine Sea plate. The inner trench wall of the forearc has preserved the entire igneous sequence formed as the Pacific plate started plunging into the mantle. To understand the reason behind subduction initiation and its influence on the extent of mantle melting in the arc, it is important to study the forearc region, especially the peridotites. Forearc Peridotites were collected on cruise KH-14-05 of the Japanese Research Vessel, Hakuhomaru, by dredging from the landward slope of the trench wall in northern Mariana area off the coast of Japan. The samples were obtained from a depth ranging from 5229m to 7590m below sea level. Harzburgites, wehrlites, and dunites were recovered by dredging, although the majority of the samples had been altered to serpentine due to high water influx. Petrographic study of the samples shows that olivine grains are altered and have given way to serpentine. Large, broken grains of enstatite have been found within the serpentine mesh, with modal percentages approaching 50–55% in several of the samples. Clinopyroxene is found occasionally and is associated, at places, with tremolite rim. Corundum is found in a few of the samples along with serpentine and saponite embedded in a matrix of a boninitic composition. The spinel analysis yields a wide range of chrome numbers that vary from 0.31–0.80, indicating different degrees of melt depletion. The TiO2 content of the spinels varies from 0.01–0.21 and wt. % Al2O3 ranges from 9–38% in the respective spinels analyzed. The low TiO2 content indicates no melt-rock interaction. The Forsterite (Fo) content of the olivines is greater than 90%, thus indicating mantle origin. The petrographic and the major element geochemical study indicate that the peridotites are moderately refractory to highly refractory and have experienced a varied degree of partial melting in the subduction regime of northern Mariana area.

COSMOCHEMISTRY OF A REFRACTORY INCLUSION FROM THE ALLENDE METEORITE: EK-459-7-2

CHARLES RYAN JEFFCOAT, ANDY G. KEREKGYARTO, MINAKO RIGHTER, JUSTIN J. SIMON, DANIEL KENT ROSS

Calcium – aluminum-rich inclusions (CAIs) are a type of refractory inclusion from carbonaceous chondrite meteorites composed of calcium, aluminum and titanium-rich silicates and oxides. CAIs are the oldest objects in the solar and their ages (~4.568 Ga) are used to establish the accepted age of the solar system. The minerals found in CAIs are among the first phases predicted to condense from a hot gas of solar composition. Consequently, CAIs represent a record of the physical and chemical conditions and processes in the earliest stages of our solar system and are important for understanding the formation and evolution of the solar system and all of its bodies (e.g. planets, moons, asteroids, comets, etc.). CAIs come in three main petrologic types where Type B CAIs are large, igneous inclusions that provide an opportunity to explore the physical and chemical conditions of the early solar system through analyzing phase relations of these coarse inclusions. There are two subtypes of Type B CAIs: Type B1s that possess a melilite mantle on their exterior and Type B2s that do not form a mantle. Mantle formation around Type B CAIs is still a poorly understood process. This work comprises a detailed study of a Type B CAI from the Allende meteorite, EK-459-7-2. EK-459-7-2 is a large inclusion that possesses a melilite mantle on only some portions of the inclusion, therefore provides an ideal inclusion to test hypotheses of mantle formation. In this work, we will introduce hypotheses of mantle formation, present results from in situ chemical analysis of this inclusion, and discuss the implications of the results from this inclusion.

SEAFLOOR GEOMORPHOLOGY OF WESTERN ANTARCTIC PENINSULA FJORDS

YURIBIA MUNOZ

Submarine glacial geomorphic features have been found in the inner shelf and in fjords in the western Antarctic Peninsula. Similar features have been mapped in other glaciated environments and in the Antarctic continental shelf giving insight into the glacial history of each region. We present multibeam swath bathymetry data collected in several fjords along the western side of the Antarctic Peninsula. We also include a comparison between the geomorphology and bay geometry, glacier catchment areas, lithology, and recent ice front velocities. We map the geomorphic features in fjords and compare the submarine geomorphology to fjord characteristics. Our ultimate goal is to understand the controls of ice flow behavior in each location. Multibeam soundings were collected using a Simrad EM120 12 kHz swath profiler, consisting of 191 beams. The survey data were corrected for anomalous readings and edited to create relief maps with a resolution of 20 meters. The bathymetric features found include grounding zone wedges, drumlins, glacial lineations, and meltwater channels. These landforms differ in size and distribution from those found in the Antarctic continental shelf, possibly resulting from varying bay geometries and rugged seafloor. Geomorphic features present also differ between fjords. Maxwell Bay and Admiralty Bay, the northernmost study areas, are characterized by a relatively flatter seafloor than other fjords at more southern latitudes. In the northern fjords, there is a high probability that the submarine landforms have been buried by post-glacial sediment deposition. The distribution of landforms in bays is complex and does not follow consistent patterns, suggesting that each fjord has a different glacial retreat history. Multiple grounding zones were found in fjords implying episodic retreat and possibly glacier readvances. The location of grounding zone wedges correlates to narrow and/or shallow areas of fjords, demonstrating the control of fjord geometry on ice retreat. The drumlins found have low elongation ratios and were not found in large assemblages, and glacial lineations are shorter in average than those found in the continental shelf. Meltwater channels are only present in the southern fjords indicating the occurrence of subglacial meltwater, although no indication of modern meltwater erosion was observed.

GROUND-BASED HYPERSPECTRAL IMAGE ANALYSIS FOR ROCK CHEMISTRY, PENECONTEMPORANEOUS CHERT, AND DIAGENETIC TRIPOLITE DEVELOPMENT IN THE LOWER MISSISSIPPIAN (OSAGEAN SERIES) ROCKS, SOUTHWESTERN MISSOURI

UNAL OKYAY, SHUHAB KHAN

Near-vertical rock faces of outcrops, such as road cuts or quarry walls, allow detailed observations of mineralogy and lithology. Recent advancements in hyperspectral sensors and developments in imaging spectroscopic methods provide an opportunity to extract detailed compositional information and identify chemical variations of outcrop faces from spectral images. Ground-based hyperspectral imaging is a fairly new method for geological studies allowing the mineralogy and lithology in near-vertical rock faces to be studied in detail with vertical and lateral continuity. The Osagean Series of the Lower Mississippian rocks are composed mainly of chert-free basal interval, bluish gray penecontemporaneous chert-bearing medial interval, and white to cream diagenetic chert-bearing (tripolitic) upper interval. Between penecontemporaneous chert and diagenetic chert intervals, there is a transitional zone may be observed characterized by white nodular chert. Diagenetic chert (tripolite) is an alteration product of chert and siliceous limestone from which carbonate has been leached by groundwater. The interaction between the host rock and fluid-flow results in chemical variations throughout the rock. This study demonstrates the application of ground-based hyperspectral data to provide information about the chemical distribution in the medial and upper intervals of the Osagean Series rocks in outcrop as well as laboratory-based data.

IDENTIFYING THE PRODUCTIVE LAYER FROM THE DOWNSCALED VELOCITIES

RAMYA RAVINDRANATHAN, ANNE CECILE LESAGE

The elastic properties of the medium are scale-dependent and in order to integrate and interpret the data obtained at different scales, upscaling and downscaling of the elastic properties is ubiquitous. Seismic data covers huge areal extent compared to the sparse well data. Describing the reservoir extent accurately is extremely crucial for production and oil recovery. So, it would be ideal to make the best possible use of the seismic data by integrating it with available well-log data to understand the reservoir limits. Downscaling using scaling functions can help us achieve this. This paper deals with two topics: Downscaling and identifying productive zones using the amplitude of Pair Correlation Function from both well-log and seismic data. Pair Correlation Function (PCF) approximation method that takes into account the effect of scattering by considering the interactions between any two points of a heterogeneous medium is considered a very effective tool in differentiating the productive from the non-productive layer. The seismic and well-log data are from northern part of South Marsh Island in the Gulf of Mexico. The Tertiary sediments of interest are generally interbedded sands and shales. The seismic and well-log data are from northern part of South Marsh Island in the Gulf of Mexico. The Tertiary sediments of interest are generally interbedded sands and shales.

WATER CONTENTS OF OFF-CRATON PERIDOTITES AND THE INFLUENCE OF MELTING

LILLIAN SCHAFFER, ANNE PESLIER

Water plays an important role in mantle melting processes and rheological properties. Interestingly, melting models can rarely predict water contents measured in nominally anhydrous minerals of natural peridotites as a function of melting. Additionally, melting models that best fit peridotite data usually predict initial water contents three to ten times higher than values ever observed in natural samples. Because most natural peridotites are metasomatized and melting models are a poor predictor of water contents, xenolith water contents are typically attributed metasomatic enrichment and not melting. However, in metasomatized peridotites, water appears decoupled from incompatible elements such as Cerium. This contradicts observations from oceanic basalts that water and Ce behave similarly. To avoid metasomatic overprinting, water contents are measured by FTIR in peridotite xenoliths from Kilbourne Hole, NM (USA), which is characterized primarily by melting signatures and no obvious metasomatism. In addition, similar peridotite xenoliths from the literature were selected from Jiande, China and the Southwest Indian Ridge. Water contents in peridotites from these locales are examined in combination with trace element data to attempt to constrain the behavior of water during melting and sub-solidus re-equilibration events. Kilbourne Hole clinopyroxene water contents show a good correlation with calculated degrees of partial melting and Yb concentrations. However, all three peridotite suites still have water concentrations higher than can be explained by traditional melting equations and experimentally calculated Nernst distribution coefficients. Alternative modeling approaches will be presented with a goal of reconciling model predictions and observed peridotite water concentrations.

EOCENE PALEOELEVATION OF THE PERUVIAN WESTERN CORDILLERA FROM FLEXURAL MODELING ALTIPLANO FORELAND BASIN STRATIGRAPHY

KURT SUNDELL, JOEL SAYLOR, THOMAS LAPEN, DUSTIN VILLARREAL, RICHARD STYRON

Recent debate of geodynamic processes active during the Cenozoic construction of the central Andes has focused on surface uplift estimates. Despite an increasing number of Neogene paleoelevation estimates, the Paleogene elevation history in this region remains poorly understood, largely because proxy materials typically used to make such estimates (e.g., soil carbonates, volcanic glasses, etc.) are either highly altered or altogether absent. We present > 6 km of Cenozoic clastic stratigraphy measured in the northernmost Altiplano of southern Peru, temporally controlled by new detrital zircon U-Pb maximum depositional ages, interpreted to be deposited in an evolving foreland basin system responding to lithospheric flexure induced by the uplifting volcanic arc in the adjacent Western Cordillera. Geohistory analysis shows tectonic subsidence rates increase from 0.04 km/Myr between 50 – 40 Ma to 0.09 km/Myr between 40 – 30 Ma, resulting in ~1.5 km of tectonic subsidence in the Altiplano by 30 Ma. We constructed a forward model using a Monte Carlo approach to calculate the geometry of a crustal load centered at past locations of the Peruvian volcanic arc. Model simulations are filtered for results consistent with our tectonic subsidence curve generated from geohistory analysis, and give a maximum estimate for paleotopography in the Western Cordillera increasing from 1 – 2.5 km between 50 and 30 Ma. These results are consistent with protracted surface uplift during Paleogene, in contrast to the spatially variable, and in some cases rapid (km/Myr), Neogene surface uplift estimates derived from volcanic glass paleoaltimetry and other proxies. These data, along with published records of crustal shortening, are best explained by multiple geodynamic processes driving Eocene–early Miocene development of high topography in the Peruvian Western Cordillera followed by a pulsed middle Miocene–present building of the central Andean plateau from west to east.

ASSESSING PRE-CENOZOIC SHORTENING OF THE SOUTH PAMIR

DUSTIN P. VILLARREAL, ILHOMJON OIMAHMADOV, BARBARA CARRAPA, BRIAN MACDONALD, MUSTAFO GADOEV

An ongoing problem in understanding the evolution of the Himalayan-Tibetan Orogen is determining how much shortening and thickening of the crust occurred before the Cenozoic collision between India and Eurasia. Whereas previously-determined values for the timing and magnitude of internal shortening in the Pamir as a whole suggest >340 km of Cenozoic internal shortening and 150 km within the Southern Pamir alone (Burtman and Molnar, 1993), recent work indicates the magnitude of shortening may be much less. In the Southern Pamir, for example, shortening formerly-interpreted as a Cenozoic nappe structure, which accounted for approximately 100 km of the 150 km, has recently been shown to be a detachment fault bounding a Cenozoic gneiss dome (Stubner et al. 2013). Our study aims to address the timing and magnitude of shortening in the Southern Pamir. The Pamir has had a protracted history of deformation due to the accretion of Gondwana terranes and subsequent tectonism. A post accretion Jurassic carbonate platform within the Central and Southern Pamir provides an ideal strain marker for evaluating the magnitude of post-suturing deformation. Further, syn-tectonic terrigenous deposits associated with deformation of the Jurassic carbonates provide means of addressing the timing of their deformation through detrital zircon maximum depositional ages. Preliminary detrital zircon results from our work and other studies indicate shortening occurred during the Early to Middle Cretaceous, prior to the collision of India and Eurasia, rather than during the Cenozoic as previously interpreted. Further, our geologic field mapping and cross section analysis suggest post-Jurassic internal shortening in the Southern Pamir is ~7 km, much less than the 50 km previously suggested. Our results of this study indicate that internal upper crustal shortening in the Pamir is significantly less than previously proposed and is largely Cretaceous in age rather than Cenozoic.

SURVEY OF EARTHQUAKES AND INJECTION/PRODUCTION WELLS IN THE PERMIAN SHALE, TEXAS, PRIOR AND AFTER THE Mw3.1 03-10-2010 EARTHQUAKE

HONGLI JING, HUA-WEI ZHOU, AIBING LI

In this study I will investigate the seismicity in the area of West Texas, which includes the Permian Shale. For the past decades, this geographic area has produced gas and oil using conventional methods; recent fast developments and widely used technology of hydro fracturing has allowed extensive development of natural gas resources from within the Permian. My study will survey the small-magnitude (<2) seismic events in the above area, from 01/01/2010 to 12/31/2010, and evaluates their correlation with fluid extraction and injection in the area, identifying and locating earthquakes. With focusing on a main event, a 3.1 earthquake occurred in this area on 03/10/2010, I will study the probable cause of it, trying to identify and evaluate its correlation with oil field activities to see if any significant increase / decrease in fluid extraction or injection in this area are related.

I will collect seismicity data of this area within the time window; also collect the area geological structure data, together with oil field injection/disposal well operation information. Use nonlinear earthquake location method to find the tempo and spatial distribution of the earthquakes. With ArcGIS, I will interpret and present the earthquakes distribution and its probable correlation with the fluid extraction/injection. The possible results may show that the majority of small earthquakes might be triggered / induced by human activity, such as fluid extraction and injection.

Poster Session

UNDERGRADUATE STUDENTS

GRAVITY MODELLING OF THE FLEXURAL RESPONSE OF LOADING OF THE NIGER AND AMAZON DELTAS ONTO THEIR UNDERLYING THINNED CONTINENTAL AND OCEANIC CRUST

RASHEED AJALA, PAUL MANN

The Niger and Amazon deltas occupy the rifted edges of conjugate margins presently located on opposite sides of the Equatorial Atlantic Ocean, so their underlying continental and oceanic crust is approximately the same age and thickness. The Amazon delta is considerably smaller than the Niger delta as it has limited surface expression due to the erosive effects of south to north ocean currents along the northeastern margin of South America. However, in the offshore area, the sedimentary wedges of both deltas are comparable in thickness with maximum thicknesses up to 12 km. This study uses gravity and seismic data to create gravity and flexural models that span the area of oceanic and thinned continental crust that underlies both deltas. These models help show the effect of the deltaic loads of both deltas on the lithosphere and are used to compare the flexural responses of their underlying crust. The results from these models show that the Niger delta is in near-isostatic equilibrium and the deltaic load is supported by a regional subsidence of its underlying crust. In contrast, the Amazon delta shows high amplitude isostatic gravity anomalies inferred to be a flexural response of its underlying crust. The load of the Amazon delta is supported by a highly thinned continental crust (~4.2 km), which has flexed by more than 2 km over a lateral distance of 500 km. I compare my proposed continent-ocean boundary inferred from the modeling of both deltas with the boundaries proposed by previous studies using other methods.

PROVENANCE ANALYSIS OF LATE CRETACEOUS SANDSTONES IN BOOK CLIFFS, UTAH

ASHLEY BOYD, JOEL SAYLOR

Two conflicting models have been proposed for the progradation of the Castlegate Sandstone as part of the evolution of the Cordilleran foreland basin during the overlapping deformation events in the Sevier fold-thrust belt, and the basement-cored, intra-foreland basin uplifts of the Laramide deformation. One model invokes an increase in the exhumation rates in the Sevier fold-thrust belt and predicts a change in sediment composition. The second model predicts that a decrease in subsidence in the foreland basin during the Laramide deformation event lead to a decrease in accommodation but predicts no systematic change in sediment composition. The purpose of this petrographic study is to use the Gazzi-Dickinson method for point counting to observe a shift in Sandstone composition that may have occurred during the formation of the Castlegate Sandstone. This project is part of a larger on-going project that uses detrital zircon to distinguish sediment supply from accommodation.

TECTONIC GEOMORPHOLOGY OF LARGE NORMAL FAULTS BOUNDING THE CUSCO RIFT BASIN WITHIN THE SOUTHERN PERUVIAN ANDES

CALLUM BYERS, PAUL MANN

The Cusco rift basin is part of a subduction-related, intra-arc Neogene rift (Interandean basin) that extends from southern Colombia to southern Peru in the northern Andes. Located between the Eastern Cordillera and High Plateaus of southern Peru, the Cusco basin segment of the Interandean basin is bounded by a series of normal fault systems, mainly downthrown to the west and southwest. The region is also the location of a change in the geometry of the subducting slab of the Nazca plate that transitions from flat-slab subduction north of the Cusco area to a 30°-dipping subduction zone to the south. The Cusco normal fault system parallels the east-west-trending Apurimac river valley and is characterized by significant Upper Miocene footwall uplift of the Willkapampa Mountains that reach elevations of 6271 m and shows northward tilting to the southwest. Previous work has shown that the normal faults are dip-slip with up to 600 m of measured displacements, reflect north-south extension, and show Holocene displacements with some linked to destructive, historical earthquakes with documented normal fault ground offsets and earthquake focal mechanisms. I have constructed structural cross sections and river profiles across the entire area to demonstrate the flexural footwall effects of this large normal fault system on the plateau peneplain. To the northwest of Cusco, the Cordillera Blanca exhibits similarly high footwall topography caused by Late Miocene normal faults and a flexed lowland, hanging wall block. Previous work has attributed activation of the Cordillera Blanca detachment faults to the passing of the subhorizontal portion of the Nazca Ridge, a 1500 m bathymetric high, beneath the Cordillera Blanca region at 5 Ma. Southeast migration of this ridge suggests that the subhorizontal portion was initially subducted beneath the Cusco region of southern Peru during the Middle Pleistocene. I summarize previous tectonic models for the formation of these large, west dipping normal faults in the Cusco region and present that they formed in response to the passing of the Nazca Ridge.

VISUALIZING SUBDUCTION ZONES WITH 3D IMMERSIVE VIRTUAL REALITY

BENJAMIN CHANG, MARGARETE JADAMEC, BURAK YIKILMAZ AND OLIVER KREYLOS

Traditionally, three-dimensional geologic features have been portrayed as two-dimensional “flat images”, with the 3rd dimension left to be inferred by the viewer. Thus, the perceived depth is often an illusion where context and detailed analysis are lost. This commonly occurs in imaging cross sections through the Earth, by the inherent two-dimensional nature of an image slice. With the progression of digital data in science, new frontiers allow for constructing interactive 3D programs to examine geoscience data. Here, we show a global survey of plate boundaries with the data rendered in the open source software, ShowEarthModel, which runs on 3D immersive Virtual Reality platforms as well as on desktop computers. In this way, earthquakes, for example, are viewed as three-dimensional point cloud data, thus conveying the geometrically complex spatial variations within Wadati-Benioff zones. Examination of subducting plate geometries in three-dimensions shows the along strike variations in slab depth and dip, as well as how multiple slabs interact at triple junctions. This provides a more accurate method of exploring three-dimensional features in the Earth by removing the illusion of depth and providing context where imagination has previously been used to fill in the gaps. Furthermore, the ability of the user to interactively explore and manipulate the hypocenter data in 3D provides the opportunity for real-time evaluation of hypotheses. By viewing subduction zones as three-dimensional fields, an infinite amount of cross sections in any direction and even subsurface horizontal cross sections can be produced. This approach to rendering earth properties broadens the scope in both Earth Science research and education by allowing for whole earth visualization.

GRAVITY AND BASIN MODELLING OF EAST AFRICA-MADAGASCAR CONJUGATE MARGINS: IMPLICATIONS FOR SOURCE ROCK MATURITY IN UNDEREXPLORED OFFSHORE BASINS

MATTHEW COPLEY, PAUL MANN

The continental margin of East Africa is a rapidly emerging hydrocarbon province as demonstrated by Anadarko's 150 Tcf gas discovery in the Rovuma delta in the offshore area of northern Mozambique. The objective of this study is to examine the underexplored East African margins of Somalia and Kenya and their conjugate margin in northern Madagascar. Rifting and oceanic spreading formed the West Somalia basin (WSB) during breakup of Gondwana from late Jurassic to early Cretaceous. Re-rifting of the area occurred as India rifted in a northeasterly direction from the eastern margin of Madagascar and formed the Mascarene basin. A northwest-southeast gravity transect across the East African margin in present-day Somalia supports a 79-km-wide band of thinned continental crust ranging from 12 to 3 km in thickness adjacent to oceanic crust in the West Somalia basin averaging 6.1 km in thickness. Published stratigraphic reports from both conjugate margins (including published information on the Jurassic-Cretaceous source rock interval) were used to create pseudo-wells whose porosity, temperature, and transformation ratios were modeled through time using Petromod. Both conjugates exhibit a similar subsidence history characterized by: 1) moderate subsidence during the Triassic and early Jurassic; 2) a rapid pulse of subsidence in the middle Jurassic; and 3) slow subsidence from the middle Jurassic to present with moderate events in the late Cretaceous, and Paleocene. Basin modeling shows that on both conjugate margins only Triassic sources reach maturity for the East African margin. For East Africa, expulsion begins in the early Cretaceous but does not reach a high transformation ratio until the Paleocene. For Madagascar, expulsion occurs later in the Eocene and does not reach a high transformation ratio. This likely occurs as a result of Madagascar's more sediment-starved island location once it has separated from the more sediment-rich East African margin.

MEASURING TECTONIC ACTIVITY USING GEOMORPHOLOGY ALONG THE CHAMAN FAULT SYSTEM

WANDA E. CRUPA, SHUHAB KHAN, JINGQIU HUANG

Collision of the Eurasian and Indian plates has resulted in two spatially offset subduction zones, the Makran subduction zone to the south and the Himalayan convergent margin to the north. These zones are linked by a system of strike-slip faults known as the Chaman fault system which spans ~900km along western Pakistan (see fig.1) (Ul-Hadi et al., 2013). There is little record of this area before 1800 with the only major recorded earthquake being the 1892 incident which stuck the town of Chaman, Pakistan (Szeliga et al., 2012, Ambraseys et al., 2003). As of now, there is no established earthquake recurrence interval, hence little scientific basis for assessing seismic potential along the Chaman fault system and possible impacts on the surrounding region (Szeliga et al., 2012). Four study areas were selected over the span of the Chaman fault: 1) North area over the Tarnak-Rud valley, 2) Spinatizha area over the Spinatizha Mt. Range, 3) Nushiki area over the Nushiki basin, and 4) South area over the northern tip of the Central Makran Mts. Landsat 8 band ratios of 7/5-6/3-4/3 and 5/7-5/4-5/1 and previously published papers were used to map faults and lithology in these areas. Geomorphic indexes of Mountain Front Sinuosity (Smf), Valley floor-to-width ratio (Vf), and Stream Length gradient (SL) were calculated and used to classify the areas in relative tectonic activity classes following method of Bull 1976. GPS data was acquired for 15 stations, out of which only 9 had useable data, and processed using a python code courtesy of Dr. Ofeigsson of the Icelandic Meteorological Office. GPS stations CHMN, MKCS, SLBG, and QLAB were decomposed into fault parallel and fault normal components and used to show fault displacement of ~7-10mm/yr in Spinatizha area. InSAR data from Szeliga et al. 2012, Furuya et al. 2008 and Jingqui Huang were also integrated to help show displacement rates along the fault system due to the poor spread of GPS data. Data over the North area shows displacement rates of 0-0.5rad/a and reveals slow moving earthquakes, similar to those along the San Andreas Fault system.

TESTING TWO MODELS OF THE EVOLUTION OF THE CARIBBEAN PLATE THROUGH COMPILATION OF JURASSIC TO RECENT RADIOMETRIC AGE DATES

MARIE NELSY KOUASSI, PAUL MANN

There are currently two tectonic models for the evolution of the Caribbean plate. The "in-situ" tectonic model proposes that the smaller Caribbean plate formed in the same location it occupies today between the North America and South America plates. The "single-arc Pacific-origin" model proposes that the Caribbean plate formed in the present-day area of the eastern Pacific and was transported over 1000 km to its present location by northeastward and eastward migration of the plate along subduction and strike-slip plate boundaries bounding it. Using ArcGIS tools, I compiled radiometric dates from ancient volcanic and plutonic rock and metamorphic complexes from all the subduction boundaries of the Caribbean plate to search for possible patterns of migration. Detrital zircon dates from sedimentary deposits were also compiled to infer the paleogeography and source areas of basins on the Caribbean plate during their deposition and can provide further clues for distinguishing the "in-situ" versus "Pacific-origin" tectonic models of the Caribbean plate. The results from the compilation show a pattern of eastward younging from Early Paleozoic to Late Cenozoic with record of continuous arc magmatism from c. 120 Ma to c. 45 Ma. This pattern is evidence of southwest to northeast and east to west motion of a single, northeast- or east-facing “Great Arc of the Caribbean” supportive of the "single-arc Pacific-origin" model.

DEFINING THE CONTINENT-OCEAN BOUNDARY AND ITS STRUCTURAL ROLE IN THE NORTHWESTERN GULF OF MEXICO FROM INTEGRATION OF SEISMIC REFLECTION AND GRAVITY DATA

DAVID LANKFORD-BRAVO, PAUL MANN

In the Gulf of Mexico (GOM), previous workers have used seismic reflection data to describe a deeply-buried sub-salt, “step-up fault” in the northeastern and north-central gulf where stretched continental crust abuts oceanic crust. From the previous studies, the vertical relief on this fault boundary varies from 1000 to 4000 meters with the oceanic (oceanward side) consistently being the upthrown fault block. Using 230 km of deep penetration seismic data, I have identified the western extension of this step-up fault in the subsalt area of northwestern GOM. In my area the fault exhibits up to 4000 m of vertical relief and is consistently upthrown on the oceanic side. I have also used gravity data to map the step-up fault that strikes N66E and extends 141 km as a continuous feature. In addition the step-up fault in this area of the northwestern GOM separates two distinctive structural provinces: the highly imbricated Port Isabel to the northwest and the less deformed Perdido foldbelt defined by large-wavelength folds structures. I propose that the continent-ocean boundary defined by the step-up fault that separates the two areas and acts as a basement ramp structure that controls the observed deformation seen at higher structural levels in both foldbelts.

X-RAY FACIES ANALYSIS OF MARINE SEDIMENT CORES COLLECTED NEAR RETREATING AND ADVANCING GLACIERS FROM THE WESTERN ANTARCTIC PENINSULA

HELENA MANUEL, JULIA WELLNER

The western Antarctic Peninsula represents one of the most rapidly warming areas of Antarctica; substantial evidence shows that the observed temperatures may be associated with ice volume changes. Fluctuations in climate conditions affect regional glacier behavior. In addition, facies variability in the sediment record can provide a means to understand the history of glacial fluctuations. This investigation focuses on different sedimentary signals recorded from the last 150 years in basins located in front of retreating and advancing glaciers. Marine sediment cores from three different areas in the western Antarctic Peninsula were studied; five kasten cores from different basins were investigated. Beascochea Bay, the southernmost area, has sediment cores from basins in front of two advancing glaciers and one from a basin in front of a retreating glacier. Flandres Bay, located in the northern region, contains a sediment core collected in a basin located in front of a retreating glacier. Lastly, Collins Bay, located between Beascochea Bay and Flandres Bay has one sediment core from a basin in front of an advancing glacier. X-radiographs of the sediment cores were classified into different facies based on the presence or absence of physical and biological structures, including size and orientation of laminations, burrows, and ice rafted-debris. Initial results suggests presence of burrows, an increase of laminated facies and decrease in ice-rafted debris towards the top of the cores in basins with advancing glaciers, and suggests few to no laminations and a lack of clear trends in basins located in front of retreating glaciers.

CALCULATION OF REGIONAL GEOMORPHIC INDICES TO CONSTRAIN THE MECHANISMS OF TECTONIC UPLIFT AND ACTIVE DEFORMATION OF THE ISLAND OF PUERTO RICO

SABRINA MARTINEZ, PAUL MANN

The island of Puerto Rico in the northern Caribbean covers an area of about 14,000 km2 and is 180 km long and 65 km wide and is densely populated by 3.4 million persons. The island is mountainous with an east-west-trending, central mountain range with its highest point of 1338 m in the geographic center of the island. The central range or Cordillera Central is flanked by narrow coastal plains on its northern and southern coasts. The origin of high topography in Puerto Rico has been attributed by previous workers to dynamic uplift of a large east-west trending anticline roughly coincident with the east-west topographic axis of the Cordillera Central and maintained by under thrust subducted slabs that converge roughly beneath the east-west axis of the island. To test the hypothesis that this topographic and structural axis is also the axis of active uplift, I have calculated geomorphic indices for 21 different watershed areas of the island that include over 50 different river systems. The geomorphic indices include a Hypsometric Integral and a Stream Length Gradient Index as defined by Stahler 1952 and Hack 1973 that assess tectonic activity based on stream and watershed behaviors. Results show that the most tectonically active watersheds correspond to the topographic axis of the island and support the idea of the anticlinal deformation of the island continuing to the present. I also compare these data to rock type and rainfall patterns to take into account these parameters on the geomorphic indices.

URANIUM, THORIUM, AND LEAD ISOTOPE GEOCHEMISTRY OF PETROLEUM SOURCE ROCKS: AN EXAMPLE FROM THE EAGLE FORD GROUP, TEXAS

ANE SLABIC, THOMAS LAPEN

The focus of this project is to investigate the U-Th-Pb isotope systematics of TOC (total organic carbon) -rich sedimentary rocks and to investigate the potential for these isotope systems to record their depositional and early diagenetic histories. The samples investigated for this project will be the Lower Eagle Ford Formation (LEFF), within the Eagle Ford Group (EFG), located in south-central Texas. Through use of in situ laser ablation inductively-coupled plasma mass spectrometry (LA-ICPMS), tests will be conducted in order to determine the uranium and thorium contents and lead isotope compositions in carbonate, phosphate, and organic rich materials. These data will be used to better understand the timing of diagenetic processes, possible fluctuations of redox conditions, and the overall age of deposition. The effective completion of this project will provide data necessary to establish the applicability of the U-Th-Pb system on TOC-rich shales, the behavior of uranium during diagenesis, the concentration of uranium found in early diagenetic minerals (such as phosphates, carbonates, and also organic material) and ultimately, the effective potential of determining depositional ages through uranium mobility in TOC-rich sedimentary rocks.

REVISED PLATE TECTONIC RECONSTRUCTIONS OF EARLY OPENING AND OCEANIC SPREADING HISTORY OF THE SOUTH ATLANTIC OCEAN

ANDREW STEIER, PAUL MANN

I have used GIS and GPlates plate reconstruction software to compile and analyze recent geologic and geophysical data to better constrain a continuous 130 Ma-present plate reconstruction for the rifting of South America and Africa and subsequent creation of oceanic crust in the South Atlantic. The plate tectonic opening models of the South Atlantic published in four previous studies differ in: 1) the initial continental fit based on locations of the continent-ocean boundary (COB) on both conjugate margins; 2) amounts of intracratonic deformation within South America and Africa during early rifting; 3) whether early rifting was symmetrical of asymmetrical; and 4) the time of early rifting in the Espirito Santo, Campos, and Santos basins. This study revises these models in the following areas: 1) using linear, basement shear zones in African and South American cratonic areas that act as "piercing points" to precisely match conjugate margins in the South Atlantic prior to breakup; 2) mapping radial dikes related to the Central Atlantic Magmatic Province (CAMP) to restore their original, sub-circular shape in North America, South America, and Africa; 3) analyzing recent marine satellite gravity to identify new fracture zones formed during early rifting (130-120 Ma) and improve the location of the COB and mapping of fracture zone trends in the oceanic crust (100 Ma-present); 4) using the improved maps of the COB to define areas of pre-breakup stretching in order to reduce continental overlap; 5) identifying upper-lower plate and volcanic-non-volcanic conjugate margins; 6) matching unique oil families on conjugate margins; and 7) realigning syn-rift salt basins on conjugate margins. The plate reconstructions of the previous authors were compared using GPlates modeling software. Layering these geologic and geophysical data onto the plate reconstructions reveals the strengths and weaknesses of each of the previously published models and allows me to propose a new plate kinematic model for South Atlantic early rifting and opening.

BEGINNING GRADUATE STUDENTS

CHARACTERIZING FRACTURE NETWORKS IN A NORMAL FAULT SPLAY ZONE

ROSS ANTHONY ANDREA, MICHAEL MURPHY, YIDUO LIU

The Plaza Blanca fault is located NE of Abiquiu, New Mexico. The fault splays into two SE-dipping, synthetic normal faults. Several studies attribute increased damage zone width and decreased fracture density from the fault core to the magnitude of fault throw. At this fault splay the damage zone becomes more complicated as two major faults interact. We employ the 2m diameter circular window method and measure fracture orientations, lengths, apertures and connective facets to determine fracture variation along and across the splay zone.

THE OPTIMIZATION OF EXTREME RAINFALL PREDICTION UTILIZING THE WEATHER RESEARCH AND FORECAST - ENVIRONMENTAL MODELING SYSTEM

PATRICK G. BLOOD, BERNHARD RAPPENGLUECK, LANCE WOOD

Numerous Weather Research Forecast - Environmental Modeling System (WRF - EMS) simulations were performed upon a cool season, or synoptically forced, high rainfall episode for the Houston - Galveston, Texas area. Previous work has shown that high-resolution modeling has historically performed poorly on weakly-forced events, such as sea breeze boundary or summer season initialized convection, while performing more favorably with strongly-forced convective events determined by frontogenesis, shortwave disturbance or trough passages. WRF - EMS simulations were run employing differing initial conditions while varying planetary boundary layer (PBL) and microphysical (mp) schemes. Statistical and graphical analyses of WRF - EMS output and verification were explored in an attempt to accurately simulate the 18 April 2009 high rainfall event that adversely affected the greater Houston area. The numerical weather prediction output was validated against Weather Service Doppler Radar (WSR - 88D) Stage IV data. High resolution land surface modeling (LSM) data was also analyzed within the WRF - EMS to discern LSM data's overall significance. Higher accuracy scores resulted from pairing advanced mp schemes with complex PBLs. The results proved that mp schemes that employed double moment mathematics and the existence of graupel, when in association with those PBL's algorithms that better resolved atmospheric dynamics, were more successful at determining the spatial and temporal nature of localized higher precipitation accumulation.

USING AIRS SATELLITE DATA TO MEASURE HOW THE ENSO EFFECTS CH4

ABIGAIL CORBETT, XUN JIANG, XIAOZHEN XIONG

The El Nino South Oscillation (ENSO) is one of the most important events that effect interannual variability in the tropical region. ENSO has important influences on tracers by disrupting the usually easterly blowing surface winds in the Walker circulation causing a relatively moist eastern Pacific and creates high air surface pressure in the western Pacific. In this study, we used AIRS data to study the CH4 concentrations over the Pacific Ocean during ENSO. We used the Southern oscillation index (SOI) to give an indication of the intensity of the El Nino in the Pacific. El Nino (La Nina) episodes have a negative (positive) SOI. When SOI was compared to the methane difference between central Pacific and Western Pacific (Lowpass filtered CH4 difference) a correlation of 0.5 (0.7) was found. We found that during El Nino events, there is much more (less) methane over the western Pacific (central Pacific). These very interesting results show that over the ocean, where there are no emission sources, the surface concentration is smaller than the upper layer and this vertical distribution can be commonly seen from the equator to the Southern Hemisphere. Additionally, this study proves CH4 in upper layers is very sensitive to vertical transport.

P-P AND SV-P WAVE RADIATION FROM VERTICAL FORCE SOURCE

ELENA ERMOLAEVA, ROBERT STEWART

There are two types of body waves radiating from a vertically vibrating circular disk of a given radius: compressional wave (P) and shear radial wave (SV). Each one has a particular radiation pattern. In a homogeneous medium, when these waves encounter a solid-solid interface at an angle smaller than a critical angle, they both reflect and convert as following: P-P, P-SV, SV-SV, and SV-P waves. In this work, only P-P and SV-P waves are considered. At the surface, a solid-air interface, up going P-P and SV-P waves both reflect and convert as down going P-P and P-SV waves. A vertical component geophone at the surface, in addition to the up going P-P wave, will also register the down going P-P and P-SV waves (a vertical projection of the latter). It is possible that these recorded P-down-P-up and SV-down-P-up waves can be separated from each other using certain data processing techniques and analyzed independently yielding results similar to a conventional converted seismic method. This theory is to be examined using synthetic seismic data.

WAVELET ANALYSIS: A POST-PROCESSING TOOL IN AIR QUALITY MODELING SYSTEM

EBRAHIM ESLAMI, YUNSOO CHOI

This study investigates potential benefits of using wavelet analysis as a post-processing method in air quality modeling problems. Understanding uncertainties related to different emissions simulations used to analysis environmental protection strategies is highly important. Among such uncertainties, those are potentially essential which are remained unaddressed during simulation process and make the quality of the available data inadequate for further uses. As a reliable approach to overcome these uncertainties, wavelet analysis is presented here in order to combine both sets of modeling outputs and monitoring data. So more accurate approximation will be achieved. The modeling dataset has been generated from a Community Multi-scale Air Quality (CMAQ) modeling system with the spatial resolution of 12km x 12km over United States for 2012 and 2013. The monitoring dataset has been selected for similar time periods using EPA's AQS database. The approach being used in this study is based on multiple resolution decompositions of modeling and monitoring data as the signals. So, the temporal and frequency information of the data could be studied simultaneously. Due to the decomposition of the signals into different frequency scales, wavelet analysis uncovers local scaling (correlation) characteristics of two aforementioned data sets. Information from both time-domain and frequency-domain of the datasets are then combined to build final dataset. In this method, air quality data are produced by fusing modeling and monitoring data instead of using each one alone. The quality of air quality simulations increases as it keeps the resolution of modeling analysis while calibrating the value with the monitoring data. Given the promising properties of wavelets, this study shows that wavelets are therefore useful for studying variational-behaving characteristics found in air quality time-series.

EARLY STAGE ORTHOPYROXENE BEARING GABBROS FROM HESS DEEP: THE INTEGRATED STORY OF AN ULTRA FAST SPREADING CENTER

ANDREW R GILFILLAN, JONATHAN E SNOW

The fast spreading ridges, associated with Hess Deep and further west at the East Pacific Rise, consists of primitive layered lower plutonic rocks. A sequence of layered lower crustal rocks is observed in ophiolite complexes abducted onto continental margins world wide, and are generally understood to be representative of the crust generated at fast spreading ridges. IODP Expedition 345 was designed to sample a relatively hard to access lower plutonic rocks and to test whether these rocks do indeed show the layering that is also seen in ophiolites. The coupled study of the lower plutonic crust at fast spreading ridges like Hess Deep, and layered ophiolites as analogs has been pivotal in developing our understanding of lower curst generation at MOR's. These rocks have strongly layered parallel foliations, which are believed to have formed early, insinuating that the lower oceanic crust formed at a fast spreading ridge. These lower plutonic rocks, along with more shallow plutonic rocks, sheeted dykes and lavas were analyzed to obtain a bulk rock composition of the local fast spreading oceanic crust. Although models accurately predicted this bulk composition, the lower crust showed evidence of early crystallized OPX, which the models do not predict. Petrography, completed on the rocks recovered by IODP Expedition 345, revealed pristine OPX in multiple thin sections, with the layered texture expected in the lower crustal gabbros clearly visible as well. Individual pyroxene grains exhibit strongly layered parallel foliations, which are believed to have formed early. Preliminary EPMA analysis on CPX and Plagioclase grains result in a range of Mg#'s and An values which plots a predictable liquid line of descent. In comparing this predictive liquid line of descent to the Mg# of the OPX and its associated Plagioclase An value, it does not appear related to the CPX's liquid line of descent. The first order petrologic and geochemical data gathered from these rocks show that they were derived from significantly different parent melts. The simplest way to explain the presence of this OPX involves crustal accretion and multifaceted melt differentiation within the lower crust.

HURRICANE DEPOSITS IN SOUTH TEXAS- PADRE ISLAND AND BAFFIN BAY

ATIF HARIZ, DONALD VAN NIEUWENHUISE

The main objective of this project is to identify overwash sediments deposited by intense hurricane events. These overwash deposits (washovers) will be studied on Padre Island, a barrier island, and correlated to washovers at Kleberg Point in Baffin Bay. Hurricanes that have made landfall in modern times are historically documented, and therefore can be correlated to the geologic record by using Pb-210 & Cs-137 dating techniques. Identifying these washovers in modern sediments can help establish a proxy and assist in identifying prehistoric hurricanes that have made landfall in the study area. The coring locations will be carefully selected based on aerial photographs of previous hurricane washover occurrences. Twelve undisturbed core samples will be extracted/obtained by using a vibracore equipped with 4m aluminum tubes measuring 7.62cm in diameter. The cores will be cut in half lengthwise, examined, photographed and studied carefully to identify hurricane washover. This includes recognizing flood and ebb sediment couplets, identifying algal mat accumulations, identifying contacts between sand and mud layers, measuring mud to sand ratios, identifying biotic components (including: foraminifera, ostracodes, molluscs, etc.), and performing laser grain-size analysis. With better defined characteristics for the identification of known deposits we should be able to more accurately define hurricane deposits in older coastal sediments and develop an empirical model of hurricane frequency and intensity along coasts around the world that have been affected by hurricanes in the distant past. Reworking may destroy small-scale and large-scale stratification, making it difficult to delineate washovers from other facies. These washovers may still be identified by using biotic assemblages and clast composition. This study will be using two known hurricane deposits on Kleberg Point because their distance from the seaward side of Padre Island, should represent significant hurricane storm surge deposits. These will be cored and compared to cores from a washover fan from the landward side of Padre Island to see the difference between proximate storm deposits (Padre Island) and more distal storm deposits (Kleberg Point). This will help develop indicators of storm intensity by comparing smaller storm deposits to larger storm deposits.

SEISMIC STRATIGRAPHY AND STRUCTURE OF A LATE JURASSIC, SOUTHEASTWARD-PROPAGATING ZONE OF RIFTING AND OCEANIC SPREADING SEPARATING CONTINENTAL CRUST OF FLORIDA AND YUCATAN, SOUTHEASTERN GULF OF MEXICO

PIN LIN, PAUL MANN

The southeastern Gulf of Mexico (SEGOM) basin formed in the late Jurassic by rifting and the formation of a wedge-shaped area of oceanic crust that tapers from west to east indicative of a west-to-east propagating system of continental rifting and oceanic spreading. The V-shaped area of rifting and oceanic crust in SEGOM points to a pole of opening in Cuba and separates continental rocks of Precambrian and Paleozoic area now forming the deeply buried basements of Florida and the Yucatan platform. I use a grid of about 50,000 km2 of seismic reflection data tied to 7 DSDP Leg 77 wells to build an integrated stratigraphic and structural history of the SEGOM within the framework of the larger-scale opening of the entire GOM. Using these data, I have mapped the following seismic pre-, syn-, and post-rift seismic sequences: 1) Paleozoic and older, pre-rift, Paleozoic basement rocks; 2) Middle Jurassic (Callovian) Louann salt equivalents, that have not been previously well recognized in the SEGOM because the salt occurs in isolated areas rather than as a continuous salt sheet as in the northern and southern GOM; these salt deposits appear to have been deposited in sediment-starved rifts with the salt being reactivated by sediment loading during the early Cretaceous, passive margin phase; I see no evidence that salt was deposited above oceanic crust in the SEGOM and conclude that the salt phase preceded oceanic spreading; 3) Late Jurassic, syn-rift subdivided into a lower, clastic and non-marine sequence and an upper, carbonate sequence formed on rift-related structural highs; these rifts form a broad V-shaped pattern that mimic the shape of the adjacent oceanic crust; continent-ocean boundaries are observed on both the Yucatan and Florida conjugate margins and form “step up faults” separating the lower-standing continental crust from the higher-standing oceanic crust; and 4) earliest Cretaceous to recent, post-rift, passive margin deposits that reflect progressive subsidence and deepwater carbonate deposition in the northern and eastern part of SEGOM.

MULTI-SCALE MAPPING OF DIAGENETIC PROCESSES IN SANDSTONE USING IMAGE SPECTROSCOPY. A CASE STUDY OF THE FRONTIER FORMATION (WYOMING, USA)

VIRGINIA ALONSO DE LINAJE, SHUHAB KHAN

Standard seismological methods using the shear wave splitting and travel times usually obtain an averaged anisotropy along the seismic ray path. We use earthquake wave radiation patterns to invert for the in situ anisotropy in the focal regions of deep earthquakes. Our inversion method is based on the explicit relationship between the equivalent force couples (moment tensors) and the anisotropy. We validated our methodology using forward modeling. We applied this method to Tonga, Mariana, Japan, Kuriles, South America and Java subduction zones. We found that a TTI model with symmetry axes perpendicular to the subducting slab interfaces can explain the non-double components in the moment tensors for nearly all earthquakes of different depths. This information provides new constraints on rock physics and mechanics on slab-mantle interactions and processes.

PLIOCENE ONSET OF ECCENTRICITY CYCLES IN THE ZHADA BASIN, SW TIBETAN PLATEAU

CRYSTAL M. SAADEH, JOEL E. SAYLOR, LOKIN CASTURI, TIMOTHY M. SHANAHAN, JUNSHENG NIE

Changes in the Asian Monsoon driven by Tibetan Plateau uplift have been invoked to explain late Miocene–Pliocene biological turnover and increases in erosion and sediment accumulation. However, documentation of pre-Miocene uplift of the plateau and evidence for early appearance of the Asian Monsoon system has called these conclusions into question. Here we present a high-resolution, late Miocene-Pleistocene (~9.2 to 2.3 Ma) stable isotopic (O and C), grain size, and depositional environment record from the high-elevation (3.5-4.5 km) Zhada Basin essential to understanding the impact and causes of monsoon variation. Both the stable isotope record and stratigraphic record indicate long-term changes in basin hydrology which may reflect the impact of regional tectonics and drainage reorganization. These long-term changes are characterized by an increase in mean δ18Ocarb and δ13Ccarb values, decrease in grain size, and onset of lacustrine deposition at 6.0 Ma which is attributed to local tectonic damming and transition from a through-flowing fluvial system to a terminal lake. This is followed at 3.5 Ma by a decrease in lake size indicated by a synchronous increase in grain size, an increase in variability in δ18Ocarb values, progradation of lake-margin depositional systems, and increase in δ18Ocarb values at lake central locations. We attribute decreasing lake size to weakening of the Indian Summer Monsoon (ISM) precipitation associated with decreased Indian Ocean temperatures. Increased variability may also reflect increased sensitivity to orbitally-paced ISM strength and glacial cycles following contraction of Hadley cell circulation and the onset of global cooling. Frequency analysis of the δ18Ocarb record further supports that Milankovitch cycles are recorded in the Zhada Basin; suggesting that insolation-driven climate change drove high-frequency environmental changes in the southern Tibetan Plateau.

ADVANCED GRADUATE STUDENTS

SEISMIC DISCONTINUITIES BENEATH THE SOUTHWEST UNITED STATES FROM S- RECEIVER FUNCTIONS

OLUFEMI AKANBI, DR. AIBING LI

S- Receiver functions along the Colorado Plateau-Rio Grande Rift-Great Plains Transect known as LA RISTRA in the southwestern United States have been utilized to map seismic discontinuities beneath this tectonically active region. Individual receiver functions were stacked according to ray piercing points with moveout corrections in order to improve the signal-to-noise ratio of the converted S-to-P phases. A mantle discontinuity, which is interpreted as the lithosphere-asthenosphere boundary (LAB), is observed along the profile with depth ranging from 80 km beneath the Rio Grande Rift (RGR) to 100 km beneath the Great Plains (GP) and 120-180 km beneath the Colorado Plateau (CP). The shallow LAB beneath the Rio Grande Rift is indicative of lithosphere extension and asthenosphere upwarp. The LAB deepens sharply at the RGR-CP and RGR-GP boundaries, providing evidence for edge-driven, small-scale mantle convection beneath LA RISTRA. Two local discontinuities beneath the southeastern Colorado Plateau are imaged at ~250 km and ~300 km and could be the top and base of the eroded lithosphere, respectively. The S receiver function images suggest that edge-driven, small-scale convection is probably the mantle source for recent extension and uplift in the Rio Grande Rift and the Colorado Plateau.

TERRAELM: TEACHING EARTH SCIENCE TO THE NOVICE

PETER ANDERSON, JONATHAN SNOW

Public science education is a not just a service for the community, it can also act as a tool by which Earth Science graduate students can themselves be trained. The classroom setting is often a relatively low-stress and fun environment for graduate students to develop their communication abilities, but it also requires them to address a much less informed audience by simplifying, synthesizing and generalizing their knowledge in real time. This method can be evaluated through a qualitative study of the participants directly involved in the school presentations. To gain efficacy in teaching to the level of your audience the graduate student participants are required by necessity to develop a speaking style that K-12 students can process and actively engage. The available literature shows that being able to break down an argument to its most fundamental components facilitates a more complete understanding of a topic in the speaker. The participants in this program learn communicative skills, which we as graduate students typically develop in graduate school, by a trial and error process. Participants in our program, improve both their overall comprehension of the subject and their ability to communicate it. Initial assessments of the merits of participation within this program show a positive correlation between participation and improved instructional ability and comprehension. We are actively evaluating additional qualitative assessments to allow us to test the validity of our initial results. This program and its philosophy provide justification for the development of new instructional techniques that take advantage of graduate students that enjoy the teaching process. Instructional development initiatives like these need to be seen as more than just civic engagement within college adjacent communities, but as a potential teaching practicum that benefits the graduate students themselves.

SUBSURFACE ARCHITECTURE STUDY OF CHANNEL BELT DEPOSITS INTEGRATING FIELD DATA WITH AIRBORNE LIDAR AND GPR IN THE FERRON SANDSTONE, HANKSVILLE, UTAH

PROMA BHATTACHARYYA, SHUHAB D. KHAN, JANOK P. BHATTACHARYA

The evolution and subsurface architecture of an ancient channel belt deposit was studied by integrating airborne Light Detection and Ranging (LiDAR), Ground Penetrating Radar (GPR) and field data in the Cretaceous Ferron Sandstone, Hanksville, Utah. Due to lack of plan view exposures, most ancient fluvial deposits are assessed from vertical cliff faces solely. This kind of two-dimensional studies might lead to misinterpretation of changes in channel orientation and erroneous estimation of channel architecture. Proper assessment of channel architecture in three dimensions is required for precise estimation of fluvial reservoir volume calculation. The studied channel belt deposit is exposed extensively in plan-view. The belt was built by migration and amalgamation of smaller unit bars. The channel belt and the unit bars within it have been mapped using LiDAR data. In this study, a GPR survey was conducted on this channel belt deposit in order to document the shallow subsurface architecture. Six GPR profiles, four flow parallel, and two flow transvers, were collected using a 200MHz antenna. A high amplitude radar reflection was encountered in all GPR profiles at 3-3.5 m which indicates the water table. Four Radar reflection patterns have been identified based on the shape, extent and inclination pattern of the reflection: 1) continuous, inclined, >15m wide and ~1.5m deep reflections; 2) >10m wide and ~2m deep steeply dipping continuous reflections; 3) Long continuous horizontal reflections of 20m length; 4) wavy small reflections of 0.2-0.5m length. In the flow traverse profiles, steeply inclined more than 10m wide and 1.5-2m deep reflections were correlated with the unit bar boundaries as seen in the plan view exposures. Flow parallel profiles are characterized by inclined stratification dipping parallel to the flow direction. Horizontal continuous reflections in these profiles are interpreted as unit bar boundaries. This radar stratigraphy can be correlated with the surface stratigraphy. Comparison of paleo-hydraulic estimation obtained from the cross-set thickness found in outcrop and GPR data indicate a slight overestimation in GPR data. In the outcrop, the cross-set thickness was about 0.08m, which is probably too low for the resolution of 200MHz antenna.

QUANTITATIVE CHARACTERIZATION OF SHALES WITHIN TIDALLY-INFLUENCED FLUVIAL VALLEY FILL DEPOSITS OF THE FERRON SANDSTONE, EASTERN UTAH - IMPLICATIONS FOR HYDROCARBON EXPLORATION

KIVANC BIBER, SHUHAB KHAN, JANOK BHATTACHARYA, MARK BARTON, CRAIG GLENNIE

This study evaluates the proportion, length, and effective properties of thin shale beds and drapes in tidally-influenced channels within a compound valley fill with a focus on estimating geologically-based effective rock properties. The Cretaceous Ferron Sandstone is an outcrop analog for fluvial-tidal systems with primary reservoirs being deposited as tidally-influenced valley filling point bars. The study outcrops expose three valley systems in Neilson Wash of Utah. Light detection and ranging derived digital outcrop models have been used to characterize shale length, width, thickness and frequency of each valley fill succession. The long and infrequent shales in Valley-1 (mean length 9.34m; mean frequency 1.5/m) were deposited in a low tidally-influenced, braided setting. In contrast, the short and frequent shales in Valley-2 and Valley-3 (mean length, 4.98m and 4.91m; mean frequency 2.7/m and 3.5/m, respectively) were deposited by more tidally-influenced meandering rivers. To estimate the effects of shale character on permeability, a sandstone/shale model was utilized. The unique character of each depositional unit was reflected in resultant Kv/Kh distributions. The valley fill deposits, V1, V2, and V3 had an average Kv/Kh ratio of 0.11, 0.09 and 0.17, respectively. More tidally-influenced reservoirs such as the studied V2 had short, but frequent shales which resulted in low Kv/Kh estimates. Estimates of Kv/Kh for valleys that predominantly contained fluvial point bar deposits with lesser tidal influence (V1 and V3) were higher. The results of this study highlight the link between shale heterogeneity, reservoir architecture, and flow parameters.

NEW EVIDENCE FOR INTRAPLATE DEFORMATION IN THE WESTERN CARIBBEAN SEA: GRAVITY, MAGNETIC, EARTHQUAKE, TOMOGRAPHY, AND SEISMIC DATA EVIDENCE FOR AN ACTIVE MICROPLATE BOUNDARY ALONG THE SAN ANDRES RIFT

LUIS CARLOS CARVAJAL, PAUL MANN

The San Andres Rift (SAR), located in the Lower Nicaraguan Rise, is an active, 015°-trending, bathymetric and structural rift basin that extends for 346 km (214 mi). In this study, we used bathymetry, proprietary gravity and magnetic data, earthquake focal mechanisms, P-wave velocity anomaly tomography, and 980 Km (608.9 mi) of deep-penetration seismic reflection lines, in order to understand the processes that generate the current structural configuration of the San Andres Rift, and Neogene volcanism reported along the Nicaraguan Rise. Based on data observations, the SAR is structurally characterized by: 1) Normal, converging, high angle, dip-slip faulting, 2) Block rotation, growth strata and negative flower structures, and 3) Bathymetric variations between the SAR flanks. Interpretations from 2D gravity and magnetic forward modeling and focal mechanisms, include: a) Different crustal affinity, thickness and deformation within the SAR expressed as surface lineaments, b) A negative gravity anomaly and high magnetism along the SAR attributed to crustal thinning with an elevated Moho surface, c) Seismicity takes place along the SAR axis with localized earthquake clusters and compression in its southwestern branch-line. We propose that Middle Miocene-Recent Cocos and Farallon slab roll-back, and Pleistocene Cocos Ridge collision are the crustal mechanisms responsible for regional intra-plate extension, eastward translation of strike-slip motion, and westward migration of Neogene volcanism in the Nicaraguan Rise.

SILICON ISOTOPE COMPOSITION OF UNGROUPED ACHONDRITE NORTHWEST AFRICA 7325

XINYANG CHEN, HENRY CHAFETZ, THOMAS LAPEN, RASMUS ANDREASEN, MINAKO RIGHTER, ANTHONY IRVING

Ungrouped achondrite Northwest Africa (NWA) 7325 is a reduced, Mg-rich cumulate olivine gabbro that mainly consists of calcic plagioclase, diopside, and forsterite. The similarities in major elemental ratios and magnetic properties with the surface rocks of Mercury suggest that NWA 7325 may have originated from this planet. Oxygen isotope values of NWA 7325 differ from those of Earth, Mars, or known asteroids but are in the range of ureilites. However, Cr isotope compositions preclude a genetic link with ureilites. The U-Pb age of NWA 7325 is 4562.5±4.4 Ma, which is consistent with an Al-Mg age of 4562.8±0.3 Ma. This study analyzed the Si isotope compositions of NWA 7325 and a suite of meteorite and terrestrial rock samples to better understand its relationship to other planetary materials. NWA 7325 has a δ30Si value of -0.45±0.05‰ (n=8), which is significantly lower than bulk silicate Earth (BSE) and angrites, but indistinguishable from chondrite. BSE has δ30Si values higher than chondrites, which led to the hypothesis that Si may have partitioned into the Earth's core during metal-silicate differentiation. However, angrites show δ30Si values even higher than BSE. Metal-silicate differentiation on the angrite parent body is unlikely because the relative small size and its oxidized conditions. Rather, it can be explained by nebular fractionation during forsterite condensation. Forsterite is suggested to be the first solid to condense from the solar nebular, which can cause ~2‰ Si isotopic fractionation between solid and gas phases. Mixing between the forsterite and gas end-members can result in different δ30Si composition in planetesimals. The difference in δ30Si values between planetary materials could be caused by variable extents of forsterite and nebular gas mixing. Higher fraction of forsterite mixing with the nebular gas during APB accretion may have caused the higher δ30Si values observed in angrites. In this scenario, the δ30Si values for NWA 7325 may indicate that it accreted from materials that inherited similar proportions of early gas and condensates as chondrites, ureilites, Mars and eucrites, but distinct from those of the angrite and aubrite parent bodies as well as the Earth-Moon system.

WELL LOG LITHOLOGY DISCRIMINATION USING ELASTIC ATTRIBUTES ONLY

ELITA DE ABREU, JOHN CASTAGNA, ERIC DA SILVA PRAXEDES

A methodology for lithological discrimination using Genetic Programming (GP) and elastic attributes derived from well logs is found to classify lithology in Upper Albian deep water tight gas sands reservoirs of the Santos Basin, Brazil, more accurately than Naive Bayesian Classification (NB), Linear Discriminate Analysis (DA) and Multiple Layers Perceptron (RN). The GPGD, when compared to the other methods, was the most accurate and robust, achieving an accuracy of 72.00% on distinguishing the three different classes of lithology (non-reservoir, sandstones, conglomerates), followed by GPMO (69.33%), GPCE (67.83%), RN (58.67%), DA (56.83%), and NB (55.50%). Similar results were obtained for the theoretical extension data set, supporting the robustness of GP approaches applied to classification problems.

GRAVITY COMPARISON OF OFFSHORE FLORIDA AND THE BLAKE PLATEAU AND ITS WEST AFRICAN CONJUGATE MARGIN

NAILA DOWLA, PAUL MANN

The outer continental shelf of the US East Coast, and northwest Africa are two underexplored conjugate margins with predicted reserves for the US East coast to be 3.3 billion barrels of oil and 32 TCF of gas within Cretaceous and Jurassic carbonate reservoirs charged by Jurassic carbonate source rocks. Predictions for the less studied conjugate margin of west Africa (Senegal to Guinea) vary widely for inferred source rocks ranging from in age Triassic to Oligocene sandstones and reservoir rocks ranging in age from Triassic to Late Cretaceous. In order to better estimate the hydrocarbon potential of both conjugate margins, crustal geometries of both conjugates have been compared to assess which margin is more favorable for hydrocarbon accumulation - or if both margins have equivalent potential. Margins with more favorable potential are generally considered those with wider rift zones with overlying sag basins and a thicker passive margin section. In the parlance of asymmetrical rifting, the margin with a wider rift zone is called here the upper plate, and the margin with a more narrow rift zone is called the lower plate. Two, 2D gravity profiles were created using refraction stations gathered from literature constrained with DSDP, IODP and ODP wells, as well as previously interpreted seismic data, and is integrated with the most recent satellite-derived worldwide gravity grid, to model the outer continental shelf basins up to 40 kms deep using gravity modelling software. This new gravity study indicates the wider, rifted margin of the Florida-Blake Plateau margin (possible rifted continental crust is 554 km wide with a thickness ranging from 22 to 12 km) may be more favorable for hydrocarbons than the more narrow and less extended margin of western Africa (rifted continental crust is 25 km wide with a thickness ranging from 25 to 11 km). The location of the proposed continent-ocean boundary is compared with the location of the boundary from previous studies.

BASALTIC SHERGOTTITE NWA 856: DIFFERENTIATION OF A MARTIAN MAGMA

JANNATUL FERDOUS, ALAN BRANDON, ANNE PESLIER, ZOE PIROTTE

Northwest Africa (NWA) 856 or Djel Ibone is a Martian meteorite, discovered as a single stone of 320 g in South Morocco in April, 2001. It is a fine-grained, highly fractured, basaltic shergottite that is Fe-rich and Al-poor rock compared to terrestrial basalts. Although the terrestrial weathering product, carbonate, is found in a few cracks, it is one of the least weathered among shergottites for a desert find. The major mineral modes of NWA 856 are 45% pigeonite, 23% augite and 23% maskelynite. The minor minerals present are ulvöspinel, ilmenite, merrillite, Cl-apatite, pyrrhotite, baddeleyite, amorphous K-feldspar and some other silica i.e. high-pressured stishovite, high-temperature cristobalite, quartz and glass. It is similar to other basaltic shergottites i.e. Shergotty and Zagami, in texture, modal mineralogy, and bulk rock trace element abundances. However, no shergottite discovered in North Africa can be paired with NWA 856 because of its larger grain size, lack of mesostasis, abundance of impact melt pockets and minimal terrestrial weathering. This meteorite was discovered about 15 years ago, but only one brief study was conducted in 2002 by A. Jambon and his group. Therefore, the objective of this study is to constrain the crystallization history of NWA 856 using textural observations, crystallization sequence modeling and in-situ trace element analysis in order to understand differentiation in shergottite magmatic systems of Mars. To serve the purpose, scanning electron microscope for thorough textural observation, electron microprobe and laser ablation inductively coupled mass-spectrometer for in-situ chemical analyses and MELTS simulations for crystallization sequences were used. We find that spinel and Mg-rich pyroxene began to crystallize first in a deep seated magma chamber. This was followed by multistage crystallization sequence with plagioclase formation during eruption of a thick phenocryst bearing lava flow and final crystallization ended up with the formation of minor phases i.e. phosphates, ilmenite, pyrrhotite, baddeleyite and silica. Moreover, Pyroxene cores were not disturbed by alteration or shock, but plagioclase was shocked into maskelynite with local incorporation of phosphates to form this ultimate Martian meteorite found on the surface of the Earth.

WATER OF THE CANADIAN CORDILLERA AND SLAVE CRATON LITHOSPHERIC MANTLE

MCKENSIE LYNN GELBER, ALAN BRANDON, ANNE PESLIER

Water, or trace H incorporated in mantle mineral defects, could be a key player in the evolution of continental lithosphere because of its influence on melting and deformation of the mantle [1]. Minerals from peridotite xenoliths are being analyzed for water by FTIR and for major elements by electron microprobe. The Alligator Lake xenoliths, representing mantle beneath the Phanerozoic belt of Western Canada, comprise lherzolites and harzburgites with contrasting trace element patterns, and are found in alkali basalts [2-3-]. Their orthopyroxene (opx) and clinopyroxenes (cpx) contain 27-150 and 46-361 ppm wt H2O respectively. These concentrations are at the low end of the worldwide range of off-craton peridotite xenoliths [4]. Slave craton peridotite xenoliths, representing deeper mantle lithosphere beneath an Archean craton, ascended in kimberlites [5]. The cpx of the Lac de Gras suite from central Slave craton have similar water contents to those of Alligator Lake but those of the opx extend to 225 ppm H2O [6]. Olivine water contents are low (< 5 ppm H2O) at Alligator Lake which may be due to H loss during xenolith ascent, while olivines at Lac de Gras contain 30-85 ppm wt H2O. Xenoliths from Jericho kimberlites in the northern Slave craton will also be analyzed to assess the role of water in cratonic roots and surrounding belts in cratonic root longevity.

DEEP STRUCTURE OF THE TOBAGO- BARBADOS RIDGE, LESSER ANTILLES, INFERRED FROM GRAVITY AND SEISMIC REFRACTION DATA

SHENELLE KIA CHERISE GOMEZ, PAUL MANN, DALE BIRD

The north-south-trending Tobago-Barbados bathymetric ridge (TBR) extends 250 km from the island of Tobago and is underlain by an early Cretaceous, metamorphosed, arc basement. The TBR extends as a reduced bathymetric ridge as far north as the island of Barbados the is underlain by accreted, hydrocarbon-rich, Paleogene sedimentary rocks of the Barbados accretionary prism. This study improves the deep crustal characterization of this lithologic transition of the TBR from metamorphic rocks in the Tobago area to sedimentary rocks in the Barbados area by integrating data from: 1) three, ~500-1000-km-long gravity transects that I constructed across Tobago Forearc Basin (TFB) and TBR; and 2) publicly-available gravity and seismic refraction data. Three 120-200-km-long gravity transects were constructed across the trend of the TBR and one 500-km-long transect was constructed parallel to the axis of the ridge from the entire area. Gravity modeling confirms that the southern part of the ridge - which forms a single, well-defined bathymetry ridge and high gravity anomaly - is underlain by a 7-km-thick, upper crust of metamorphic rocks to 12.5N latitude that appear to be a direct continuation of the exposed metamorphic basement of Tobago. North of 12.5N, TBR becomes a more complex, multi-branched bathymetric ridge with a moderate gravity anomaly that extends for 126 km to the island of Barbados and is likely metasedimentary at depth. I propose that the metamorphic rocks of the southern TBR and metasedimentary rocks beneath the island of Barbados represent an unsubductable and elongate metamorphic terrane that was accreted around 110 Ma to the east-facing, proto-Caribbean subducton zone. As this event occurred in the Early Cretaceous, the terrane is now buried to a depth of 12 km. North of 12.5N, this same setting along the proto-Caribbean subduction zone is occupied by a co-linear belt of metasedimentary rocks with a distinctive gravity signature. In both areas, these rocks would have no source potential because of their low to intermediate metamorphic grade. Mature source rocks known from shallow oil wells and natural seeps in Barbados must exist at a higher level than these metasedimentary rocks inferred at depths of 10 km and greater.

FAULT DETECTION USING PRINCIPLE COMPONENT ANALYSIS: A CASE STUDY IN THE BAKKEN FORMATION

ISMOT JAHAN, JOHN CASTAGNA, M. AMIN KAYALI

Seismic fault detection using principle component analysis (PCA) can be used to interpret fault distribution and orientations in the Bakken formation. The PCA fault attribute shows significantly different, and geologically more plausible, three dimensional fault distributions than conventional seismic attributes, such as curvature and coherence, which cannot resolve differing fault patterns in the Upper, Middle and Lower Bakken members and the Threeforks formation. Two distinct fault trends in the NE-SW and NW-SE directions are observed in the Middle Bakken formation and are apparent on dip and strike attributes derived from the PCA analysis. Fault cuts interpreted from well log missing section correlate well with the PCA fault attribute.

IMPACT OF DROUGHT ON CO2

ANGELA KAO, XUN JIANG, EDWARD OLSEN AND THOMAS PAGANO

CO2 data from Atmospheric Infrared Sounder (AIRS) is used to compare with the in-situ measurements to see if the AIRS satellite retrievals are able to capture the surface CO2 variations. AIRS CO2 data has similar seasonal pattern with the Total Carbon Column Observing Network, which shows the surface uptake and release of CO2 from the biosphere. And many other results have proven that the AIRS CO2 retrievals are able to capture the surface CO2 variations. CO2 fluxes such as biomass burning and net exchange between the biosphere and atmosphere in wet and dry years are conducted to explore the impact of drought on CO2. The results show that AIRS CO2 is able to capture the surface CO2 variations with droughts. There is more CO2 released into the atmosphere during dry years, which is possibly due to increase of biomass burnings and wildfire events. Less vegetation results in decrease of CO2 uptake from the biosphere, which leads to increasing concentration of CO2 in the dry years.

STABLE AND RADIOGENIC MAGNESIUM ISOTOPE STUDY OF TWO PETROGRAPHICALLY SIMILAR B1 CAIS

ANDREW G. KEREKGYARTO, T. J. LAPEN, C. R. JEFFCOAT, R. ANDREASEN, M. RIGHTER, D. K. ROSS, J. I. SIMON

Ca-Al-rich inclusions (CAIs) are some of the earliest formed crystalline solids in our developing solar nebula. Their mechanisms and timing of formation provide clues about the conditions in and development of the early solar system. The short-lived radionuclide 26Al, which decays to 26Mg (t1/2 = .705 My, β+), is a major early heat source and useful as a high-precision chronometer for early solar system solids. Since 26Al is an extinct radionuclide, only relative ages can be established via resolving the initial radioactive 26Al present during formation, commonly discussed as (26Al/27Al)0. This is done by correlating excess radiogenic 26Mg of phases with their 27Al/24Mg values to show an isochronous relationship. Using 'bulk rock' (in this case, bulk CAI) measurements or fragments representing the whole for isotope studies are appropriate when the system in question remains closed throughout its history. If any mineral-scale isotopic resetting or even complete isotopic homogenization subsequent to formation, bulk measurements would average everything and still represent the initial formation. Evidence of open system conditions has been increasingly seen in CAIs, implying that bulk measurements of these objects would not reflect the timing and conditions of initial formation. Using more conventional means of mineral separation and wet chemistry reduce/remove spatial resolution and homogenize sub-mineral isotopic variations. We prefer in situ methods (LA-MC-ICPMS) correlated with detailed petrographic evidence to resolve these sub-mineral and mineral scale isotopic variations.

STUDY OF DIAGENETIC FEATURES IN UPPER ALBIAN RUDIST BUILDUPS OF THE EDWARDS FORMATION USING GROUND-BASED HYPERSPECTRAL IMAGING AND TERRESTRIAL LASER SCANNING

DIANA KRUPNIK, SHUHAB KHAN

Ground-based hyperspectral imaging is a technique for development of digital outcrop models which are useful for detailed qualitative and quantitative sedimentological analysis to augment the study of depositional environment, diagenetic processes, and hydrocarbon reservoir characterization in areas which are physically inaccessible. For this investigation, ground-based hyperspectral imaging is combined with terrestrial laser scanning to produce mineralogical maps of Late Albian rudist buildups of the Edwards formation in the Lake Georgetown Spillway in Williamson County, Texas. The Edwards Formation consists of shallow water deposits of reef and associated interreef facies. It is an aquifer in western Texas and was investigated as a hydrocarbon play in south Texas. Hyperspectral data were registered to a geometrically accurate laser point cloud-generated mesh with sub-pixel accuracy and were used to map compositional variation by distinguishing spectral properties unique to each material. More calcitic flat-topped toucasid-rich bioherm facies were distinguished from overlying porous sucrosic dolostones, and peloid wackestones and packstones of back-reef facies. Ground truth was established by petrographic study of samples from this area. This research integrates high-resolution datasets to analyze geometrical and compositional properties of this carbonate formation at a fine scale.

EVALUATION OF WRF/CHEM PLANETARY BOUNDARY LAYER PARAMETERIZATIONS AND ITS IMPACTS ON O3 SIMULATION FOR DISCOVER-AQ 2013

RUIXUE LEI, ROBERT TALBOT

In order to explain this unusual major and trace element zonation observed in these garnet samples, we have constructed kinetic models to reproduce the measured zoning profiles and relate model input parameters to potential garnet growth rate laws and garnet growth conditions. We considered a range of variables including the range of temperatures for garnet growth from 300-520°C as well as two different growth mechanisms for garnet. Results from these models indicate that garnet nucleation must occur above 300°C, but below 400°C in order to preserve the secondary peak of HREEs at the rim. Additionally, garnet growth best fits an interface-limited growth model, rather than a diffusion-limited model, as the interface-limited model allows for the formation of a broader central peak of HREEs when compared to the diffusion-limited model. Furthermore, our results indicate that a simple thermal history adequately explains their growth history within a Cretaceous subduction zone. This implies that a more complicated subduction history involving repeated burial, fluid influx or change in temperature is not necessary. In order to explain this unusual major and trace element zonation observed in these garnet samples, we have constructed kinetic models to reproduce the measured zoning profiles and relate model input parameters to potential garnet growth rate laws and garnet growth conditions. We considered a range of variables including the range of temperatures for garnet growth from 300-520°C as well as two different growth mechanisms for garnet. Results from these models indicate that garnet nucleation must occur above 300°C, but below 400°C in order to preserve the secondary peak of HREEs at the rim. Additionally, garnet growth best fits an interface-limited growth model, rather than a diffusion-limited model, as the interface-limited model allows for the formation of a broader central peak of HREEs when compared to the diffusion-limited model. Furthermore, our results indicate that a simple thermal history adequately explains their growth history within a Cretaceous subduction zone. This implies that a more complicated subduction history involving repeated burial, fluid influx or change in temperature is not necessary.

STRUCTURAL ANALYSIS OF THE TAYRONA SOUTHERN CARIBBEAN DEFORMED BELT, OFFSHORE GUAJIRA PENINSULA, COLOMBIA

STEPHEN LESLIE, PAUL MANN

The Southern Caribbean Deformed Belt (SCDB) is an accretionary prism that extends over 1300 km offshore of the Caribbean coastlines of Colombia and Venezuela. The SCDB defines the subduction boundary separating downgoing oceanic and oceanic plateau crust of the Caribbean plate beneath the Caribbean Sea from overriding, continental South American Plate in northern Colombia. The “Tayrona” portion of the SCDB is a ~500 km long, entirely submarine, section of the SCDB extending sub-parallel to the Colombian coastline located in deepwater offshore of the Guajira Peninsula and Santa Marta Massif. A grid of nineteen high quality 2D seismic reflection profiles (~2200 line km) provided by Spectrum Geophysical image the Tayrona SCDB and provides the basis for my structural analysis. Interpretation of the 2D seismic data in two-way time reveals at least nine major thrust related folds grouped inboard of the frontal thrust of the SCDB. The thickness of sediments along the top of the Caribbean plate outboard of the SCDB varies by an order of magnitude from west to east - with over 4 km of sediments in the western area proximal to the Magdalena Fan and ~400 m of sediments to the east towards the Aruba gap. The variability of sediment thickness directly influences the structure and style of folding and faulting along the Tayrona SCDB from west to east - most noticeably in the degree of shale diapirism that is apparent within the accretionary prism. Structural analysis of a series of seismic reflection profiles, converted from two-way time to depth, provides estimates of the degree of shortening that has occurred across the margin and also defines several phases of deformation that have occurred along the Tayrona SCDB.

SEISMIC IMAGING OF THE MANTLE WEDGE USING PRESTACK KIRCHHOFF MIGRATION

LUCHEN LI, YINGCAI ZHENG, HAO HU

Cold and dense lithospheres sink into the mantle at the subduction zone after their ephemeral residence on the surface of the Earth. As the lithosphere descends into the mantle, it induces a mantle wedge flow and in the mean time volatiles released from the subducting plate could interact with the overlying mantle wedge to produce reflectors that might be visible to the seismic waves. Imaging the spatial distribution and reflectivity of these reflectors may provide important clues to understand various processes in the mantle wedge. In this research, I will use the prestack Kirchhoff migration technique to image the mantle wedge. The deep earthquakes will be seismic sources which can illuminate the reflectors from below and the underside-reflected waves will be eventually recorded by teleseismic seismometers. I plan to use three types (pxP, sxSH, and sxP) of seismic waves for the imaging, with each type being sensitive to different properties of the discontinuity. The pxP phase is an upgoing P wave from the source and reflected as a P wave to the receiver. The “x” means a discontinuity at x-km depth above the earthquake. The sxSH denotes SH-wave reflection with similar ray paths compared to the pxP. The third phase sxP, represents an upgoing S wave reflected (mode conversion) reflected as a P wave to the receiver. Using all three types of phases: pxP, sxP and sxSH, will yield comprehensive understanding of the elastic properties of the discontinuities. To mitigate the influence of uncertain source location determination and uncertain seismic velocities, we use surface reflections (pP, sP and sS) as reference phases for the traveltime calculation. The pxP, sxP, and sxSH are precursors to the respective surface reflections, pP, sP, and sSH. The goal of this thesis work is to image all mantle wedges for global subduction zones and compare mantle wedges across different subduction zones due to different subduction characteristics (e.g., subduction rate, slab angle). However, my first study area will be for Tonga mantle wedge due to its abundant deep seismicity.

THE ADIABATIC MELTING OF IMPURE MANTLE: A POTENTIAL PETROGENETIC MECHANISM FOR INTRAPLATE OIB TYPE MAGMA DURING OROGEINIC STRETCHING

YIPENG LI, ALEXANDER ROBINSON, CLAUDIA LING

The hetero-genetic mantle presents very distinct bulk composition and mineral assemblages, and controls their different solidus to result in variable compositions of their partial melting. In general, the garnet-pyroxenite, eclogite, Amphibole bearing garnet peridotite and phlogopite bearing peridotite in mantle depth correspond to the materials from subducted oceanic lower crust, subducted oceanic upper crust, Na-rich metasomatized mantle and K-rich metasomatized mantle, all of their solidus much lower than garnet peridotite. In order to clarify the melting relationships of these “impure mantle” during orogenic late stage stretching, the AlphaMELTs thermodynamic program is employed in this paper to model the adiabatic decompressional melting of garnet-pyroxenite and eclogite in this paper under 1200 °C, 1300 °C, and 1400 °C mantle adiabats. The results show that the pressure window from c.a. 20 kbar to c.a. 13 kbar on 1300 °C mantle adiabat can generate 10-20% degree OIB type melting. This compensate the deficiency that pure or limited water bearing mantle peridotite is not able to generate melts or only generate extreme limited volume of ultra-Alkaline melts in garnet stable pressure on 1300 °C adiabat. This modeling is realizable for the generation of Cretaceous intraplate OIB type lava in the red formation basins on the north margin of Tibetan Plateau. The Late Paleozoic to Triassic subduction can leave oceanic slab fragments in the deep mantle, the Cretaceous orogenic stretching attenuated the lithosphere, induced the basin subsidence and decompressed the impure mantle to be melting, and formed the OIB lava inter-bedding with red formations.

MANTLE MIXING: IMPLICATION FROM CENTRAL LENA TROUGH K-RICH BASALTS IN ARCTIC OCEAN

XIANG LING, JONATHAN SNOW, YIPENG LI

Mid-Ocean Ridge Basalt (MORB) with a potassium enrichment (K-MORB) was observed in the central Lena Trough (CLT) in the Arctic Ocean.In contrast to other MORBs and OIBs, the K-enriched MORBs are higher in SiO2, Al2O3, K2O, K2O/TiO2, and lower in FeO. Their trace elements present strong enrichment in Rb, Ba, Nb, Ta; weak positive anomalies in Sr and Ti; negative anomalies in Th and U; as well as the steeper HREE than MORBs. Low [Dy/Yb]PM and La/Yb ratios concentrate from 1.21 to 1.36 and from 3.77 to 6.60, respectively, indicating a source with no obvious garnet present under low pressure. [Ba/Th]PM scatters from 2.51 to 5.06 indicating a heterogeneous mantle source. The Low Th/U ratio from 2.97 to 4.89 excludes the possibility of an amphibole-bearing source. The trace element quantitative modeling indicates that 5% degree of partial melting from 0.97% Phl and 0.03% Amp mixing with 99% DM (70% Ol, 10% Cpx, 20% Opx mantle peridotite) is consistent with the incompatible elements pattern of CLT basalt. P-T estimation shows 1198-1212oC/4-7kbar as the possible melting condition for CLT basalt, which is along the 1200oC mantle adiabat. Whereas the chemical composition of north Lena Trough (NLT) basalt is similar to N-MORB, and the P-T estimation ranges from 1312-1339oC/8-12kbar, which corresponds to 1300oC normal mantle adiabat. The CLT basalt bulk composition is the mixture of 40% of the K-enriched endmember and 60% N-MORB-like endmember. The K-enriched endmember is 3-5% degree of partial melting of a source (0.97% Phl, 0.03% Amp, and 99% DM) along 1200oC mantle adiabat from 8 to 10 kbar modelled from AlphaMelts. The N-MORB-like endmember is similar to NLT basalt in composition. Therefore the N-MORB-like mantle and the K-enriched mantle coexist in the CLT region. The CLT thus represents the transition from cold lithospheric mantle to hot oceanic mantle, which is simultaneous to the Arctic Ocean opening.

ALONG-STRIKE VARIATIONS IN CRUSTAL ARCHITECTURE OF THE CONJUGATE MARGINS OF BRAZIL AND ANGOLA IN THE CENTRAL SOUTH ATLANTIC

PATRICK LOUREIRO, PAUL MANN, DALE BIRD

The conjugate margins of Brazil and Angola have been the sites of some of the largest, and most productive oil fields in the world the past decade. While four decades of previous studies have produced several different models for early opening of the South Atlantic Ocean, there is no clear consensus on how these margins formed, their relative degrees of symmetry and asymmetry, and the deeper, crustal architectural constraints on the distribution of hydrocarbons on the conjugate margins. Low-pass filters applied to regional free-air gravity grids (Sandwell 2014) reveals a crustal signature imprinted by continental rifting during the Valanginian, and defined by a necking domain (zone of crustal thinning) and a distal domain (zone of thinned continental crust landward of the continent-ocean transition). Seismic reflection data from the conjugate basins of Brazil (Espirito Santo, Campos, Santos) and Angola (Kwanza, Benguela, Namibe) showed the presence of large listric normal faults and change in crustal seismic character at the transition between the necking and distal domain. My 2D gravity modeling of the conjugate basins is consistent with the observations from both the gravity grids and seismic reflection data. The gravity models match particularly well with the 10-km-wide zone of pronounced extension between the necking and distal domains which also underlies the pre-salt carbonate sag basin. The Santos basin (Brazil), Kwanza basin (Angola), and Benguela basin (Angola) all fall into the hyperextended lower plate domain, while their conjugates all exhibit narrow/ non-hyperextended crustal structures associated with upper plate margins formed during asymmetrical rifting. Lower plate margins range from 100-150 km (Kwanza, Santos, respectively) compared to their 30-50-km-wide upper plate, conjugate margins in west Africa (Namibe, Campos, respectively). The variations observed in crustal architecture along-strike can be attributed to reversals in the polarity of the upper and lower plates while across strike variations can be explained according to the relative widths of the necking and distal domains.

HERTZ-MINDLIN CONTACT MODEL FOR BIOT MEDIA

SHARIF M MORSHED, EVGENY CHESNOKOV

Hertz-Mindlin contact model is one of the few rock physics model that can be used to link seismic velocities with stress and pore pressure. However, classical Hertz-Mindlin model accounts only equal size spheres, therefore suitable only for modeling well sorted porous sandstone. To overcome such limitations, we introduced pair distribution function in the Hertz-Mindlin model to account for wide range of grain size distribution. We also made connection between Hertz-Mindlin model and Biot media. The result is improved understanding of seismic velocities for known porosity, fluid type and fluid saturation.

BASEMENT CONTROLS ON ALONG-STRIKE VARIABILITY OF THE VOLCANIC MARGINS OF URUGUAY AND SOUTHERN BRAZIL INFERRED FROM DEEP-PENETRATION SEISMIC REFLECTION DATA

KYLE ROBERT REUBER, PAUL MANN

The present-day passive margins of offshore Uruguay and southern Brazil have been classified as volcanic margins that formed during the Aptian opening of the South Atlantic Ocean. For this study, I used 15,000 kms of 40-km-long record depth-migrated seismic data from a widely-spaced survey of the Punta de Este and Pelotas Basins of Uruguay and southern Brazil. Interpretation of these data indicate rapid, along-strike variations in the amounts of volcanic material and degree of continental stretching. Onshore basement rocks underlying the conjugate margins of South America and Western Africa include both Pan-African-Brasiliano foldbelts and stable cratons. Three lateral abrupt variations in the amount of syn-rift volcanism and the amount of continental stretching is observed from these data and correlates well with the type of basement that was rifted: 1) The northern extent of the Pelotas basin is underlain by nominally rifted basement, of the Dom Feliciano fold belt and is characterized by thick packages of seaward-dipping reflectors (SDR's) and underlying, igneous crust. This 275 km-wide zone separates the continental and oceanic crustal domains; 2) the southern Pelotas Basin is underlain by the Polonio High, a prominent feature of the Uruguayan Shield. This margin segment shows evidence of minimal continental thinning and an 85km wide zone of SDRs and igneous crust west of the oceanic domain. 3) the southern Uruguayan Punta de Este Basin is the offshore domain of the Pampia fold belt and is characterized by moderately thinned continental crust, and variable amounts of igneous material. Evidence for rift related volcanism varies from minor occurrences to SDR packages reaching 13km in thickness. The implications for hydrocarbon exploration are primarily the existence of syn-rift targets and the variability along the margin. Regions where continental thinning has occurred, and where pre-existing fold-belts are present, have higher syn-rift prospectivity than regions where the transition from continental crust is abrupt.

LATE PALEOZOIC EVOLUTION OF THE GREATER COLORADO TROUGH: LINKING SOURCE TO SINK IN THE ANCESTRAL ROCKY MOUNTAINS

TYSON MICHAEL SMITH, JOEL SAYLOR

The late Paleozoic Ancestral Rocky Mountains (ARM) are a series of basement-cored uplifts that stretched across the interior of North America (NA) and are an ancient example of intracontinental deformation. Two proposed models of ARM development prevail: Model A attributes ARM deformation to compression due to diachronous east–west collision between NA and Africa/South-America along the Ouachita-Marathon-suture, predicting an east-to-west pattern of uplift activation. Model B attributes ARM deformation to hypothesized shallow slab subduction off the southwest coast of NA, predicting south-to-north sequencing of activation. The Uncompahgre Uplift and the Ancestral-Frontrange define the core of the ARM. These northwest-southeast trending uplifts were thrust onto adjacent lithosphere creating a series of foreland basins. Between the two uplifts lie chain of depocenters: the Eagle Basin, Central Colorado Trough, and Taos Trough (i.e. Greater CO Trough), which were intermittently yoked and separated as a function of late Paleozoic eustasy and tectonics. The Greater CO Trough is well-placed to investigate the spatial and temporal patterns of ARM tectonic activity through the interplay of uplift activation and sediment dispersal patterns. Combining data that I have collected with work cited in literature produce a sequence of Greater CO Trough grain size and gross depositional environment maps spanning the late Paleozoic. These data are applied in tandem with detrital zircon U-Pb and paleoflow measurements to elucidate regional dispersal networks, the control of depositional mode (e.g. fluvial, eolian, etc.) on detrital zircon populations, and relative abundance of material supplied by different source areas. This approach provides insight into the tectonic activity and catchment evolution recorded in the Greater CO Trough. Not surprisingly, these data clearly demonstrate that tectonics exerted dominant control on facies variability and basin architecture. Interpreting these results within the context of simplified ARM causal mechanisms presented above is problematic. This is evidenced by along strike variability of coarse clastics along the margins of both the Uncompahgre Uplift and Ancestral-Frontrange. However, additional data could assist in testing predictions of hypothesized ARM drivers. I present the benefits that (U-Th)/He and eHf of detrital zircons will yield in the arenas of source area identification exhumation.

GROUND-BASED HYPERSPECTRAL REMOTE SENSING AND TERRESTRIAL LASER SCANNING OF THE EAGLE FORD FORMATION

LEI SUN, SHUHAB KHAN, DARREN HAUSER, CRAIG GLENNIE

This study uses ground-based hyperspectral remote sensing and terrestrial laser scanning data to map the Eagle Ford Formation in west Texas. The Eagle Ford Formation consists of alternating layers of limestones, marlstones and volcanic ashes with high total organic content deposited during the Cenomanian-Turonian oceanic anoxic event. Detailed remote sensing study of the outcrop can be utilized as an analog to the source rock and reservoir at the subsurface, and provide valuable geological information as well as foresight about hydrocarbon exploration. Hyperspectral remote sensing acquires electromagnetic radiation in numerous bands in a continuous spectrum and holds great power to resolve mineralogical compositions of scanned materials without physical damage. Ground-based hyperspectral imaging scans the geologic outcrops at close ranges with very fine spatial resolution (millimeters to centimeters). Pixel-based spectra matching of study material with reference standards are performed by spectral angle mapper algorithm, which revealed the variations of calcite and kaolinite concentrations among the alternating layers. Classifications allowed quantifying rhythmic layers of limestones, marlstones and ashes as well as other lithological variations in the Eagle Ford Formation. Laboratory spectroscopy is used to assist with mineral identification and image classification. Thin section petrography and X-ray diffraction data verified the classification results of hyperspectral remote sensing. Terrestrial laser scanning (TLS) is a novel LiDAR technique which provides fast and accurate 3D models and enables detailed stratigraphic and structural studies including bed thickness variations, lateral continuities, fracture density and orientations, etc. Stratigraphic bedding planes are automatically detected by machine learning techniques from the 3D geometry. And calibrated laser intensity data is utilized in lithology identification. Combining hyperspectral remote sensing and TLS data, this study creates 3D outcrop models with detailed mineralogical compositions, and provides geologic analogs to extract geo-mechanical characteristics. The utilization of these new techniques in geo-statistical analysis provides a workflow for employing remote sensing in resource exploration and exploitation.

LATE CRETACEOUS TO RECENT PALEOGEOGRAPHY AND SEQUENCE STRATIGRAPHY OF THE NICARAGUAN PLATFORM, WESTERN NICARAGUAN RISE: CONTROLS ON HYDROCARBON SOURCES, RESERVOIRS AND SEALS

LUCIA TORRADO, PAUL MANN, LUIS CARLOS CARVAJAL, JAVIER SANCHEZ

Late Cretaceous to Recent sediment deposition along the Nicaraguan platform, western Nicaraguan Rise, has evolved from a tectonically-controlled Late Cretaceous-Early Eocene mixed shallow to deep marine carbonate/siliciclastic shelf to an Early Miocene to Recent, tectonically-stable, shallow-marine carbonate platform. The Cenozoic sequence records three cycles of transgression and regression, starting with Early Eocene rodolitic/algal carbonate shelf that interfingered with marginal silicilastic sediments derived from exposed areas of Central America to the west. During the Middle Eocene, this mixed siliciclastic/carbonate platform shelf evolved into an entirely carbonate platform across which rimmed and isolated reefs formed. A Late Eocene forced regression resulted in widespread erosion and subaerial exposure along most of the platform and was recorded by a regional unconformity. The Oligocene-Early Miocene sedimentary record includes a southeastward-trending deltaic wedge that emanated from the proto-Coco River. Within this mainly clastic environment, restricted carbonate banks developed at the southernmost area of the platform. The Late Miocene to Recent marks a period of strong subsidence with development of small pinnacle reefs. The petroleum system elements of the Nicaraguan platform include: 1) Eocene fossiliferous limestone source rocks, 2) Early to Middle Eocene patch and pinnacle reefs, Middle Eocene calcareous turbidites and Oligocene fluvial-deltaic reservoirs, and 3) Seal intervals that include regional unconformities and Eocene-Oligocene intraformational shales.

CHARACTERIZE METHANE SOURCES IN HOUSTON AND THE BARNETT SHALE AREA USING Δ13CH4

SHUTING YANG, ROBERT TALBOT, LEI LIU, XIN LAN

Methane (CH4) is an important greenhouse gas with its mixing ratio increasing in the global atmosphere. Identifying fingerprints of methane emissions is critical to our understanding of potential impacts of extensive nature gas operations in Houston area and in the Barnett Shale area. Measurements of the methane mixing ratio and δ13C in methane were sampled using a mobile laboratory coupled with cavity ring-down spectrometer (CRDS). Thirty-two sources in total were measured and investigated in the two studied areas. -51.5‰ and -49.2‰ overall δ13CH4 signatures were calculated for the Barnett Shale and Houston areas respectively. Several repeated measurements were conducted to investigate the variability of source δ13CH4 signatures. A case of unexpected massive methane leaking detected near the San Jacinto River Fleet site was investigated. The approach applied by this study can capture high methane signals and further identify the source of methane leaks. The results and findings can supply valuable references for the local emission inventory and atmospheric models input.

SURFACE DEFORMATION IN QUETTA VALLEY, BALOCHISTAN, PAKISTAN

JINGQIU HUANG, SHUHAB D. KHAN, ABUDUWASITI WULAMU, WANDA CRUPA, ABDUL S. KHAN, DIN M. KAKAR, AIMAL K. KASI

On February 2011, several ground fissures up to ~1.8 km in length appeared in the Quetta Valley, Balochsitan, Pakistan. It is not clear what caused the sudden occurrence of these fissures. The region is tectonically active and bounded to the west by several regional strike-slip faults including the north-south striking left-lateral Chaman fault system that slips at ~10 mm per year. Several large earthquakes have occurred recently in this area, one fatal 6.4 magnitude (Mw) earthquake occurred on October 28th, 2008. Some parts of Quetta Valley are subsiding; GPS data from two stations (QTIT and QTAG) in Quetta that span mid-2006 – 2009 recorded subsidence rates of ~10 cm per year. Although subsidence in urban areas is generally attributed to groundwater depletion, it is not clear whether ground fissures and subsidence are only caused by water withdrawal or related to tectonics of the region. This study is designed to quantify and assess the source of surface deformation in Quetta Valley using InSAR, GPS, gravity, seismic reflection and earthquake centroid moment tensor data. To detect and map the spatial-temporal features of the processes that led to the surface deformation, we used a time series of 40 ENVISAT ASAR (Advanced Synthetic Aperture Radar) images spanning from 2003 – 2010. Small Baseline Subset (SBAS) techniques was used to investigate surface deformation. Nine GPS stations within the InSAR footprint were used to compare with the DInSAR result. Five seismic lines totaling ~60 km, acquired in 2003, were used to map the blind faults beneath Holocene alluvium in the Quetta Valley. The integrated results from five different geophysical techniques were used to quantify anthropogenic and tectonic caused surface deformation in this region.