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Abstract Volume

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Oral Presentations

Title: Tectonics of Bannu Basin and Its Relation to the TransIndus-Salt Ranges fold-thrust belt in Northern Pakistan

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The TransIndus-Salt Range, located in northern Pakistan, is one of the most tectonically active fold-and-thrust belts in the world. Located at the western Himalayan syntaxis, this region experiences two types of deformation; strike-slip deformation, originating from the sinistral Chaman fault and compressional deformation due to the continental-continental collision of the Eurasian and Indian tectonic plates. The arcuate nature of the Bannu basin, located at the western end of the TransIndus-Salt Range fold-and-thrust belt, is believed to be due to pre-existing basement geometry by previous studies. This work builds on this idea in that the bending is also controlled by the distribution of salt. Using 2D seismic interpretation, subsurface structures were mapped showing evidence of salt diapirism in areas of transpression. This further strengthened the idea that Infra-Cambrian salt act as the detachment for Bannu basin and not shale as in previous studies. The general structural geology of the Bannu basin shows thin-skinned deformation with many similarities to the Salt Range. Moreover, seismic interpretation also suggests that the Bannu basin consists of two detachment horizons; the main detachment is the Infra-Cambrian salt and the other is the Eocene shale/salt layer. Two cross-sections have been generated to show the general structures of Bannu basin. A Bouguer anomaly map was interpreted for basement structural trend.

In addition, this region has been actively explored for hydrocarbons since the mid-nineteenth century. However, the Bannu basin is the least explored in comparison to the Salt Range. Due to the similarities in their structure and stratigraphy, the results in Bannu basin were compared to the Salt Range. By understanding the subsurface structures and tectonics of the TransIndus-Salt Range fold-and-thrust belt, we can better detect features of petroleum generation and accumulation for future exploration.

Detrital zircon constraints on sediment supply versus accommodation controls on Late Cretaceous foreland basin stratigraphic architecture in the Book Cliffs, central Utah

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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 fold-and-thrust belt. Variations in wedge geometries provide an opportunity to evaluate the effects of sediment supply versus accommodation on its foreland basin architecture. The stratigraphy shows that the eastward progradation rate increases between the Lower and Upper Castlegate Sandstone. The overlying Bluecastle Tongue and Price River formations, as well as the laterally equivalent Farrer and Tuscher formations, show a decrease in eastward progradation rates. Rapid progradation may be caused by increased sediment supply from either rapid exhumation in the Sevier thrust belt or changes in the sediment source. Alternatively, reduced accommodation within the foreland basin from structural uplifts associated with Laramide deformation, or a transition from flexural to dynamic subsidence, could produce the same observed rapid wedge progradation. Detrital zircon U-Pb geochronology of Campanian clastic wedges will be used to enable identification of qualitative and quantitative changes in sediment provenance. Changes in sediment provenance can be identified based on temporal and spatial variations of detrital zircon U-Pb ages within the foreland basin. Twenty-one samples from 5 measured sections along depositional strike and dip directions were analyzed using the LA-ICPMS at the University of Houston. Initial detrital zircon U-Pb data reveals a significant upsection and spatial shift in provenance between all wedge boundaries. Quantitative comparisons using previously published detrital zircon U-Pb provenance data indicates an overall decrease in Mesozoic eolianite and North American passive margin source areas. This decrease is also coupled with an overall increase in a magmatic arc and Mogollon Highland source area from the south, indicating an overall decreasing thrust-belt source area and increase in a new southern sediment source area during the middle to late Campanian.

Quantitative characterization of shale drapes within tidally-influenced fluvial valley fill deposits of the Ferron Sandstone, Eastern Utah - implications for subsurface exploration

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The study of outcrops is a viable tool in facies architecture and reservoir characterization studies. Combination of high resolution digital outcrop data and traditional field data creates a single visualization, integration and interpretation environment platform where critical information can be extracted. When combined with conventional field geology, the digital outcrop models offer 3 dimensional geological realizations with sufficient quantities of numerical data, facilitating a robust, reproducible and quantitative analysis. The study outcrop, Turonian Ferron Sandstone in South-Central Utah, was composed of five cut-and-fill episodes each having laterally and vertically accreting point bar deposits with variable tidal influence and their associated channel forms that are exposed in a series of strike and dip aligned exposures. Tide-influenced river deposits have been an interest for the oil industry, but not much published data are available which relate shale character data to effective permeability estimates within the architectural element scale. To address this lack of data, detailed shale length, width, thickness and frequency measurements were taken from high resolution digital outcrop models. Shale length and frequency characteristics of the valley fills reflect the degree of tidal influence. While long and infrequent shales exist in Valley-1 (mean length 10.4m; mean frequency 1.5/m), short and frequent shales exist in Valley-2 deposits (mean length, 6.39m; mean frequency 2.7/m). Moreover, shale length to width ratios reflect the degree of confinement of the valleys. Valley-1 is the least confined valley with an L/W ratio of 2.2, while Valley-2 and 3 have the most confined with almost equidimensional shales with a mean L/W ratio of 1.07 and 0.85, respectively. The unique character of each architectural unit within the incised valley fill deposits results in different k_v/k_h distributions, indicating that the deposits would behave differently under conditions of fluid flow. The valley fill deposits, V1, V2, and V3 have an average k_v/k_h ratio of 0.031, 0.012 and 0.022, respectively. Moreover, there is a systematic decrease in k_v/k_h ratio for all valley allomembers from older to younger channel belts. This might be indicative of increased tidal influence as the valleys backfill. Therefore, it is critical to consider variations in shale character and related permeability distributions in fluvial valley fill deposits at the architectural element scale when modeling analogous reservoirs such as the McMurray Formation of the Athabasca Oil Sands or Frio Formation of the Gulf of Mexico, USA.

Post-Rift Subsidence of the Abyssal Gulf of Mexico

J. M. Cannon, M. Murphy, J. Saylor, Y. Liu

We examine the subsidence history of the Gulf of Mexico (GoM) abyssal plain using geohistory analysis of seismic stratigraphy at eight locations across the northern gulf, and compare the result with predictions from geodynamics, lithosphere flexure, and paleogeographic reconstructions. We find two distinct episodes of Cenozoic subsidence 65 Ma – 49 Ma and 34 Ma – Recent not attributable to thermal contraction or sediment loading referred to here as residual subsidence. We evaluate changes in residual subsidence rate and magnitude in terms of sublithospheric and crustal/surficial processes and find that none of models uniquely predict the Cenozoic spatiotemporal pattern. However the Paleocene-Eocene event appears more compatible with sublithospheric shallow mantle convection near the leading edge of the Farallon/Cocos slab, while the Oligocene to Recent event correlates well with lithosphere flexure imposed by progradation of a thick wedge of sediment and salt.

Si Isotope Variations in Authigenic Quartz Crystals: Implication for Low Temperature Fractionation

Xinyang Chen, Henry Chafetz, Thomas Lapen, Rasmus Andreasen

Silica is a common diagenetic constituent in shallow marine carbonates that occurs in a variety of crystal forms and morphologies. Silicification in carbonates has occurred throughout the geological record from the Precambrain to Quaternary. However, Phanerozoic silicon cycle is profoundly different than the Precambrian system as biogenic silica greatly influences the Phanerozoic silicon distribution. Modern biogenic siliceous deposits have been predominately influenced by diatoms due to their great abundance and short life time. In contrast, Mesozoic silicon cycle has been mainly controlled by sponges.

Multi-collector inductively coupled plasma mass spectrometer (MC-ICP-MS) was used to characterize the millimeter scale variation in Si isotopic ratios as well as bulk Si isotopic composition for sedimentary chert and associated authigenic quartz crystals from the upper part of Cretaceous Edwards Formation at central Texas. The δ^{30}Si values of the euhedral megaquartz samples have an almost 6‰ range, from -2.91 to +2.94‰ with a mean value of -0.29‰ (n = 112). The distribution of δ^{30}Si values in each measured megaquartz sample show great variability even on a sub-millimeter scale with at least 3.75‰ variation within a single grain, suggesting a lack of Si isotope homogenization at this scale during diagenesis. The distributions of *in-situ* δ^{30}Si data reveal that megaquartz crystals generally have light cores and heavy outer rims, which suggests the initial deposits originated from a solution that was depleted in ^{30}Si. A Rayleigh type kinetic fractionation model explains the observed Si isotope variation within grains. Consistent with recent experimental studies of Si fractionation factors, the paleothermometry calculations indicate the quartz crystals precipitated from pore fluids with temperatures close to 7^{0}C.

Evolution of a Shelf- Margin Minibasin, Northern Gulf of Mexico

Tucker Conklin

A 3D seismic cube donated to the University of Houston by Petroleum Geo-Services was used to study the evolution of a shelf- margin minibasin located approximately 160 km off of the coast of Louisiana. Depositional packages were broken out and classified based on observed changes in internal characteristics and lapout patterns. Reconstruction of the depositional history of the minibasin reveals information relating to how depositional styles and architecture change over time in response to eustacy, sediment supply, and salt tectonics.

Four shelf- margin deltas are identified and classified into two sub- categories, unstable, fluvial influenced deltas, and stable, wave influenced deltas. Slope failure driven by continued uplift of two salt diapirs bounding the study area on the eastern, and western flanks caused numerous shallow water mass transport complexes to redeposit sediment. Slope channels found in the largest packages erode into the underlying substrate, and functioned as a shelf to slope sediment bypass mechanism. Deltaic packages were occasionally capped by muddy transgressive wedges. Prodelta muds and hemipelagic drape deposits also fill portions of the minibasin.

A sequence stratigraphic framework was used in order to relate the sediment packages to the sea-level record. Deltaic deposition occurred during lowstand periods, and account for the largest packages present in the minibasin. Muddy wedges were occasionally deposited during major transgressions, with hemipelagic sediment deposits forming during highstands. Fluvial influenced deltas show signs of a higher sediment supply and rate, which is indicated by syndepositional internal deformation and larger thicknesses. The wave influenced deltas present are stable, with no deformation found. The constraining effects of the minibasin in relation to the depositional styles of the deposits were examined. When compared to their open shelf- edge counterparts, the deltas present were more likely to develop shelf to slope bypass systems in the form of slope channel complexes, regardless of wave or fluvial influence.

Modeling dispersion in a convective decay planetary boundary layer using the WRF large eddy simulation model.

Cuchiara, G. C., Rappenglück, B.

The mean and turbulent characteristics of the planetary boundary layer (PBL) play an important role in determining the transport, storage and dispersion of atmospheric pollutants. Most pollutants are emitted or chemically produced within this layer and its diurnal evolution plays an important role in determining pollutant dispersion pathways and the chemical properties of atmospheric pollutants. Despite the huge effort of the science community in air quality monitoring and research worldwide, most emphasis has been placed on daytime surface air pollution. Conversely, the vertical and horizontal transport processes operating during the transition from day to night and during the nocturnal stable layer have received significantly less attention. Nevertheless, some research efforts suggest that processes operating in three dimensions throughout these different stability conditions may have a significant impact on near-surface pollutant concentrations.

This work is an assessment of the capability of the Weather Research and Forecast Large Eddy Simulation (WRF-LES) to model passive scalar dispersion, and thereby simulate stack plumes interaction at different heights and varied stability regimes, impacting the nocturnal surface layer and/or the nighttime residual layer aloft. Also, an alternative set of diffusion equation is proposed to study the dispersion of pollutants caused by an evolving turbulence in the transition process occurring during the sunset period. The large eddy simulation technique resolves turbulent structures down to inertial scales and is well suited to investigate the multiscale nature of dispersion. A set of experiments with different characteristics were conducted to simulate the dispersion of scalars (such as inert tracer species) in distinct planetary boundary layer stability conditions. Periodic lateral boundary conditions were enforced for the velocity, temperature and scalar, and a no penetration/absorption condition was enforced for the scalar at the lower and upper boundaries so that the total scalar mass within the domain was conserved. The statistical results are compared with other large eddy simulations. Results suggest that WRF-LES model is a promising tool to evaluate the impact of evening boundary layer transition processes and to access the potential impact of tall-stacks in the atmosphere pollution.

Two oxygen fugacities recorded in a single Type-B1 calcium – aluminum-rich inclusion: insights into conditions of the early solar nebula.

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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.). Fassaite (Al – Ti-rich augite) is an important phase found in CAIs because it harbors relatively large concentrations (up to ~16 wt. %) of the multivalent Ti (present as Ti^{3+} and Ti^{4+}). The amount of Ti^{3+} relevant to Ti^{4+} is dependent upon the oxygen fugacity of the system fassaite is forming in. Hence, Ti^{3+}/ Ti^{4+} in fassaite may be used to estimate the oxygen fugacity of CAIs and possibly the solar nebula. Results from EPMA analyses of fassaites were used to calculate fassaite Ti components and estimates of oxygen fugacities in a single Type B1 CAI. Calculated oxygen fugacities suggest the fassaites in this particular object experienced two distinct oxygen fugacities during formation. We use detailed textural and chemical evidence to suggest that one population of fassaites record a more oxidizing environment associated with the isolated interior of the CAI, whereas another population of fassaites remained in equilibrium with a more reducing nebular gas during formation. The results of this study indicate oxygen fugacity within the solar nebula was likely heterogeneous in the formation region of CAIs.

Influence of spatial resolution on NO_2 column measurement comparisons during DISCOVER-AQ Texas

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This project is an inter-comparison of NO_2 column measurements in the Houston, TX region during the third deployment of the Discover-AQ campaign in September 2013. This analysis includes data from the Ozone Monitoring Instrument, Pandora Spectrometer, and in situ aircraft data and ground data. The spatial heterogeneity of NO_2 in Houston causes comparison mismatches due to the differences in spatial resolution of the measurements. Pandora measures a cone between the sensor and the sun covering the spatial area of a few kilometers in the early afternoon whereas OMI measures the average column over a much larger spatial area (13x24km^2 at nadir). OMI and Pandora column measurements do not have information about the distribution of NO_2 vertically. However, ground and aircraft in situ data show information at the ground level through the lower troposphere. Assumptions about the vertical distribution of NO_2 helps create in situ inferred columns for comparison to Pandora and OMI. The lifetime of NOx is often less than half a day in the summertime US boundary layer leading to high spatial variability in urban areas with the highest concentration of NO_2 near emission sources. The OMI larger footprint leads to the loss of information about NO_2 spatial variability. A proposed solution for using OMI data at a smaller scale is tested and can be validated using higher spatial resolution measurements. This tool uses a CMAQ derived spatial weighting kernel representing the distribution of NO_2 over the OMI pixel footprint, and the spatial weighting kernel is used to distribute the OMI measured NO_2 at a smaller spatial scale. These comparisons will show the advantages and limitations of each data set for future analysis on the distribution of NO_2, especially in urban regions.

SUPRA-CANONICAL INITIAL $^{26}Al/^{27}Al$ FROM A REPROCESSED ALLENDE CAI

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Ca-Al-rich inclusions (CAIs) are some of the earliest formed crystalline material in our solar system. Their mechanisms and timing of formation provide clues about the conditions in and development of the early solar system. The short-lived radionuclide ^{26}Al, which decays to ^{26}Mg ($t_{1/2}$ = .705 My, β^+), is a major early heat source and useful as a high-precision chronometer for early solar system solids. The applicability of the ^{26}Al-^{26}Mg radioisotope system for early solar system chronology is reliant on that assumption that the Solar System initial $^{26}Al/^{27}Al$ ratio (i.e the 'canonical' value) is constant throughout the Solar System. Since ^{26}Al is an extinct radionuclide, only relative ages can be established via resolving the initial radioactive ^{26}Al present during formation, commonly discussed as $(^{26}Al/^{27}Al)_0$. This is done by correlating excess radiogenic ^{26}Mg of phases with their $^{27}Al/^{24}Mg$ 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. Our primary focus is the nearly monomineralic melilite mantle of a large B1 CAI from the Allende carbonaceous chondrite meteorite.

Studies have consistently converged on a $(^{26}Al/^{27}Al)_0$ for early forming CAIs of ~5-5.2 $x10^{-5}$. This marks the birth of our solar system and is dubbed the 'canonical value'. We present a well-fit regression yielding a $(^{26}Al/^{27}Al)_0$ resolvably higher than canonical as well as a disturbed isochron yielding the canonical value just a few millimeters apart.

NEAR-SURFACE GEOPHYSICAL INVESTIGATION OF THE 2010 HAITI EARTHQUAKE EPICENTRAL AREA: LÉOGÂNE, HAITI

Eray Kocel, Robert R. Stewart, Paul Mann, and Li Chang

The 120 km^2 Léogâne fan-delta in southwestern Haiti is about 5 km from the epicenter of the devastating magnitude 7.0 Haiti earthquake of January 12, 2010. The flat plain of Léogâne fan-delta experienced some of the worst shaking, destruction of buildings, and loss of life caused by the Haiti earthquake. This intense shaking of the fan-delta area was attributed by previous workers to either activation of a blind thrust fault ~4 km beneath the Léogâne fan-delta, or to strike-slip motion along a shallow, ground-breaking fault that ruptured the uppermost part of the fan-delta. Our research team from University of Houston and Haiti Bureau of Mines and Energy collected shallow seismic and gravity data in the fan-delta where previous studies of earthquake aftershocks, coastal uplift of coral reefs, and radar interferometry all indicated the maximum amount of coseismic uplift. Our objective was to acquire geophysical information on the subsurface stratigraphy, structure, and material properties of the fan. S-wave studies revealed an average velocity of 180 m/s for the first 30 m. These velocity values suggest that the near-surface sediments at Léogâne are class E (National earthquake hazard reduction program). Interpretation of the various seismic methods indicates prolonged sedimentary environments of fluvial channeling and channel migration to a depth of 350 m as expected in this fan delta setting. There is no clear evidence on our reflection lines for substantial faulting in the seismically weak, fan-delta sediments. Integrated geophysical data analyses indicated south dipping seismically weak layers on the southern end of the Léogâne fan and a possible fold structure. The sudden, coseismic upheaval of the ground surface above the blind thrust combined with extreme shaking of the seismically weak sediments contributed to the destructiveness of the earthquake on the Léogâne fan delta.

Coronal Induced Production of Ozone From a Thunderstorm During DISCOVER-AQ 2013

Alexander Kotsakis, Barry Lefer, Gary Morris, Ken Minschwaner, Anne Thompson, Douglas Martins, Richard Orville

In September of 2013, NASA's DISCOVER-AQ (DAQ) air quality campaign took place in Houston, Texas. During the DAQ campaign, 58 ozonesondes were launched from the University of Houston-Main Campus and Smith Point, Texas combined. Surface ozone production was not active during the 2013 DAQ Texas campaign with the Houston region only recording two eight-hour average ozone exceedance days during the campaign. The lack of surface ozone during September 2013 was due to certain meteorological conditions including frequency of thunderstorms, which aided in limiting ozone production. While thunderstorms limit ozone production near the ground, ozone can be efficiently produced aloft from electrically active thunderstorms. On September 5th, 2013 an ozonesonde was launched near an electrically active storm and enhanced tropospheric ozone was observed. While there was evidence of entrainment of biomass burning emissions, we conclude that the enhanced free tropospheric ozone was most likely from coronal induced (CI) ozone production. We calculated a CI ozone production rate of 1062+192 moles of O_3 per flash.

Influence of Climate Change and Meteorological Factors on Houston's Air Pollution: Ozone a Case Study

Lei Liu*, Robert Talbot, and Xin Lan

We examined the past 24 years of O_3 data and selected meteorological parameters in Houston, Texas which has been one of the most polluted cities in the United States. Both 1-hr and 8-hr O_3 exceedances have been reduced significantly down to single digit yearly occurrences. We also found that southerly flow has increased by a factor of ~2.5 over the period 1990-2014 likely suppressing O_3 photochemistry and leading to a "cleaner" Houston environment. The sea breeze was enhanced greatly from 1990-2013 due to increasing land surface temperatures, pressure gradients, and on-shore winds. These patterns driven by climate change produce a strengthening of the sea breeze which should be a general result at locations worldwide.

Slab tearing triggered the Cretaceous igneous activity in the northern Gulf of Mexico

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Igneous activity during the Cretaceous (ca. 108 – 65 Ma) in the northern Gulf of Mexico (GoM) region has been a subject of debate. This igneous system, characteristically derived from the sublithospheric mantle, consists of alkaline basalts predominantly, and nepheline syenites, carbonatites and phonolites. It spans from Arkansas, Mississippi to West Texas. Understanding its mechanism is fundamental in understanding the tectonic and thermal history of the GoM basin.

Competing hypotheses include: 1) It results from the Bermuda hotspot as the North American plate passes over it; 2) Edge-driven convection produces melts at the continent-ocean boundary; and 3) Reactivation of preexisting lithospheric structures leads to asthenospheric upwelling and melting. While these models explain some observations, there exist unresolved issues, respectively. Age distribution does not match predicted pattern of the hotspot model. The edge-driven convection model predicts a distribution of igneous rocks that is opposite to the observation. Enriched geochemical signature of the igneous rocks questions the reactivation model in which much more evolved samples are expected.

Alternatively, tearing of subducted Farallon slab at sublithospheric-depth can explain its age distribution pattern and geochemistry. The Farallon slab could reach the mantle 1000+ km inboard beneath central and eastern US. As the asthenosphere beneath the Farallon slab is warmer and/or more buoyant than the cold oceanic slab, the Farallon slab becomes mechanically unstable. Ultimately, the slab breaks-off and a tear nucleates in the slab during the middle Cretaceous. Sub-slab materials rise through the slab gap, followed by decompression melting at the base of lithosphere, and emplacement of the magma into weaker, thinner parts of the lithosphere such as the Mississippi Embayment and the GoM margin. The slab tear propagates both parallel to and perpendicular to the strike of the slab, i.e. southeastward to Jackson Dome in Mississippi, and westward to Balcones and Trans Pecos in Texas. The magmatism ceases at the onset of shallow-angle subduction of younger Farallon slab. This model explains the Cretaceous sublithosphere-derived igneous rocks at a regional scale, and provides boundary constraints for reconstruction of the Farallon slab back to ca. 110 Ma.

Comparison of upscaling methods with special emphasis on Pair Correlation Function to identify the reservoir from the non-reservoir

(Ramya Ravindranathan, Dr. Anne Cecile Lesage, Dr. E M Chesnokov)

The elastic properties of rocks are scale-dependent and in order to integrate the data obtained at different scales, upscaling of the elastic properties is ubiquitous. Upscaling refers to the prediction of elastic properties at lower frequencies from those at higher frequencies. In other words, going from the high frequency (sonic 2-20 kHz) scale to the low frequency scale (seismic 5-100Hz) by substituting randomly inhomogeneous media by a homogeneous media with equivalent elastic properties. Different upscaling methods are applied to the logging data available for wells penetrating Miocene clastic sediments of South Marsh Island and the results are compared. We start with the simple averaging technique that is just an arithmetic method where, at each point of the heterogeneous medium, the deviations also called the fluctuations of actual strain field from the strain field averaged over a representative volume are neglected. Later, we introduce the Backus method that is only applicable if the length of elastic waves propagating in the medium is much greater than the thickness of an individual layer. The simple average is a static approach while the Backus is a quasi-static approach and both does not take into account the frequency dependence of elastic-wave velocities caused by scattering or intrinsic attenuation. The difference in the results obtained is attributed to different theoretical backgrounds underlying these methods.

The aim is to understand the issue of upscaling due to the elastic scattering in a formation at different scales. The upscaling method based on pair correlation function approximation provides more accurate upscaling estimate of velocities at surface seismic exploration scale than Backus and simple averaging. Pair correlation function is determined as a product of fluctuations of random functions at two arbitrary points and is a very effective tool in differentiating the productive zones from the non-productive zones.

Testing geodynamic models for surface uplift of the Central Andean Plateau through basin analysis and volcanic glass paleoaltimetry in southern Peru

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Geodynamic models describing the formation of the central Andean plateau show either rapid or steady topographic rise driven by incremental or rapid removal of dense lithospheric material, respectively. Wholesale or piecemeal foundering of mantle lithosphere predicts pulses of surface uplift that may be uncorrelated with steady crustal shortening, and where the surface expression scales with the scale of the foundering block. Lithospheric removal by ablative subduction or thermal weakening predicts slower uplift that is spatially and temporally coincident with crustal shortening. Distinguishing between these models requires integrating the subsidence and deformation history of hinterland basins with the record of uplift and formation of the central Andean plateau. Research on these topics has been focused in Bolivia and Argentina; there has been relatively little investigation in southern Peru.

We present new stratigraphic, geochronologic, and stable isotopic data for temporally overlapping, yet spatially separate Cenozoic intermontane basins of southern Peru. In the context of newly logged stratigraphic sections, these data allow for reconstruction of the rate and distribution of Cenozoic deformation and intermontane basin filling, and give insight into the uplift history of the northern extent of the central Andean plateau. We document the former through basin analysis combined with published records of timing of crustal shortening, and the latter using a novel approach to paleoaltimetry via stable isotope analysis of deuterium (^{2}H) in hydrated volcanic glass. Because water-glass isotopic fractionation during hydration is temperature-independent, volcanic glass paleoaltimetry circumvents potential complication highlighted by recent advances in climate simulations: non-adiabatic decreases in temperature with rising topography. Guided by such advances, our preliminary results suggest rapid uplift need not be coupled with crustal shortening in the central Andean plateau, and are consistent with a combination of geodynamic mechanisms.

Interpreting Backwater Effects on Fluvial Style and Architecture in a High-Gradient Compound Incised-Valley Deposits: Example from Cretaceous Ferron Notom Delta, Southeastern Utah.

Mohammad S. Ullah, Janok P. Bhattacharya

Incised valleys formed by fluvial incision during the periods of falling sea level, and are intrinsic components of non-marine sequence stratigraphic models, as they mark the regional sequence boundary. Non-marine sequence stratigraphic models for incised valleys predict systematic changes in fluvial style from lowstand through transgressive to highstand system tracts, assuming a constant rate of marine transgression. Downstream base-level influence on fluvial style however, can be highly variable, and may produce less predictable pattern. The main purpose of this paper is to evaluate the change in plan-view style of rivers from their upstream to downstream versus extent of the effects of backwater length recorded within a Cretaceous compound incised-valley fill in the Ferron Notom Delta, Henry Mountain region, southeast Utah. It was hypothesized that the backwater length, which is proportional to river flow depth and inversely correlated to river slope theoretically controls the effects of base-level change to propagate upstream. Previous studies on modern Mississippi river valley demonstrated that channel, channel-belts in a coastal-plain valley experience predictable morphological and sedimentological changes as they enter their backwater length, and characterized by rivers that are aggradational, avulsive and distributive in nature.

This paper, for the first time, attempts to test these hypotheses in an ancient compound valley fill by detailed facies architectural analysis of channel and bar deposits from vertical measured sections and estimation of backwater limits from paleo-flow depth measurements in combination with measured changes in base level, tidal range and fluvial slope along an extensively exposed fluvial long profile. Three major erosional surfaces partitioned the compound valley fill into three sequences that have noticeable morphological and sedimentological differences from the upstream to downstream area. All three incised-valley fills in the downstream area shows a vertical translation from fluvial to tidal facies at the top of the valley. This suggests the rivers entered into their backwater length at the later phase of valley filling causing a systematic vertical decrease in overall grain size as well as an upward increase in preserved dune height and bar thickness. The valley fill deposits at the upstream area, which is roughly 15 km southwest, however, lie beyond the reach of the backwater effect and hence do not show any tidal influence, and consist of much coarser facies within channel bodies of relatively low width-thickness ratio.

GPS Derived Ground Deformation (2005 – 2014) within the Gulf of Mexico Region Referred to a Stable Gulf of Mexico Reference Frame (SGOMRF)

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This study investigated ground deformation derived from the current GPS geodesy infrastructure in the Gulf of Mexico region. The positions and velocities of 164 continuous GPS (CGPS) stations (> 4 years) are aligned with a local reference frame, designated the Stable Gulf of Mexico Reference Frame (SGOMRF). This local reference frame was established for precisely delineating ground motion associated with fault creep, salt dome uplift, and land subsidence in the Gulf of Mexico region. The SGOMRF was realized by employing a 14-parameter Helmert reference frame transformation from the International GNSS Service Reference Frame of 2008 (IGS08). Fifteen long-term (> 5 years) CGPS stations were used as reference stations to calculate the 14 transformation parameters. The root-mean-squares (RMS) of the velocities of these 15 reference stations achieved 0.2 mm/year in the horizontal and 0.3 mm/year in the vertical directions within the local reference frame. GPS observations presented in this study indicate significant land subsidence in the coastal area of southeastern Louisiana, the greater Houston metropolitan area, and two cities in Mexico (Aguascalientes, Mexico City). Significant spatial variation of subsidence rates was observed in both Mexico City and the Houston-Galveston area. The CGPS sites in the southern Houston metropolitan area indicate generally less subsidence (< 5 mm/year) compared to the CGPS sites in northern area (~ 20 mm/year). One CGPS site (MMX1, 2008 – 2014) in eastern Mexico City recorded 266.3 mm/year steady subsidence. GPS stations in southeastern Louisiana indicate minor (< 6.0 mm/year) but consistent subsidence over time and space. This suggests the occurrence of sediment-compaction or tectonic subsidence. Coherent southward horizontal movements (~1 mm/year) were observed in southeastern Louisiana, which could be the result of faulting activities.

Poster Session

4D AVO INVERSION ENHANCEMENT BY GATHER CONDITIONING USING DYNAMIC TIME-WARPING

Ayodeji Babalola(University of Houston), Fred Hilterman (Geokinetics Inc.), and Robert, R. Stewart (University of Houston)*

ABSTRACT

AVO processing workflows are designed to preserve relative amplitude between offset gathers making them ideal for reservoir characterization. But in the event where the traces are not aligned, post-processing techniques predicated on windowed cross-correlation are employed to adequately condition seismic data. A new application of dynamic time-warping algorithm, a technique used for speech recognition by matching similarities in two discrete time series that are out of phase is applied to non-linearly correct for time mis-alignment. A case study with time-lapse dataset from the Norne field, Norwegian Sea is presented showing significant improvement in Bayesian inversion for elastic properties as the traces are warped prior to the Inversion process.

LA VELA BAY, OFFSHORE FALCON BASIN, WESTERN VENEZUELA: EASTERN EXTENSION TO THE LA PERLA CARBONATE RESERVOIR TREND

Joan M. Blanco

Discovery of the 16 TCF La Perla gas giant in 2009 was the first major carbonate-hosted giant reservoir discovered in northern South America. Moreover, the La Perla discovery was found in the northern part of the Gulf of Venezuela on the exotic Caribbean plate and did not involve the more familiar hydrocarbon habitat in Venezuela of foreland basin clastic reservoirs sourced by the Cretaceous passive margin. We describe the La Vela carbonate reservoir, offshore Falcon basin, western Venezuela, located 170 km southwest of La Perla and consisting of an Early Miocene reefal reservoir directly overlying igneous-metamorphic basement with associated Miocene age source rocks. The reservoir produces both light-medium oil and gas and more than half of the reservoir presents effective porosities between 8 and 15%, and permeabilities less than 15 mD. We used 960 km2 of 3D seismic data tied to 40 wells to map the reef reservoir facies over an area of 11000 km2. The thickness of the limestone varies from several meters to 150 m. Well data show that the facies is a shallow carbonate ramp with localized reef buildups. We use curvature and other attributes for the seismic volume to show that variations in porosity are controlled by diagenetic effects rather than by fracturing. The level of deformation is much less than in the neighboring areas of the onland, inverted Falcon basin to the south. We have identified good seals at local and regional scales that correspond to maximum flooding shale units. We use paleogeographic maps to show a possible Miocene reefal carbonate trend running along the southern edge of the exotic Caribbean plate and linking the La Vela area to the La Perla area of the Gulf of Venezuela.

COMPARISON OF BOUNDARY LAYER RETRIEVAL METHODS USING AEROSOL LIDARS

Authors: Vanessa Caicedo, Barry Lefer, Amy J. Scarino, Ray Hoff and Ruben Delgado

Methods for boundary layer height derivations using aerosol backscatter have proven as a reliable method for continuous monitoring of the boundary layer (BL). However, these methods require careful and thorough manual examination of individual results and have yet to become automated derivations. This is due to a few limitations in the nature of BL height (BLH) retrieval using aerosol backscatter. All aerosol derived BLH methods are based on two assumptions: 1) constant concentration of aerosols within the BL and 2) stronger backscatter in the BL with a strong negative gradient when reaching the top of the BL indicating low aerosol concentrations in the free troposphere. Common mistakes in BLH measurements usually result from algorithms mistakenly identifying the residual layer as the top of the boundary layer during nighttime. This happens when the residual layer contains more aerosol concentrations than the nocturnal stable layer, which in turn creates a greater negative gradient at the top of the RL. Similarly, lofted aerosol layers present the same challenge. To better identify BLHs and create a more robust automated algorithm, this study will test the gradient method and a Haar wavelet method across two ceilometers, an airborne High Spectral Resolution LIDAR, an elastic LIDAR and a micropulse LIDAR.

Tectonostratigraphy and sedimentary architecture of the Nicaraguan Rise and Colombian Basin

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The Caribbean region covers only 0.4% of the world's surface but has an extremely complex tectonic history due to the interaction of the North American, South American and Pacific plates. Five HiRes 2D seismic sections (ca 1450 km) capture the tectonic and sedimentary architecture from the Honduran Borderland to the Colombian Basin. Six tectonostratigraphic sequences (TSS) are identified along the Honduran Borderland (HB), Upper Nicaraguan Rise (UNR), Lower Nicaraguan Rise (LNR), and Colombian Basin (CB). 1) TSS6 solely appears in the HB and UNR and corresponds to a thick succession of igneous rocks, metamorphic rocks, and meta-sedimentary rocks that represents the deposition of pre-Cretaceous rocks affected by the collision of the Suina Terrane and Chortis Block by the middle Cretaceous (ca 72 Ma). High amplitude reflectors delineate complex compressive structures within this tectonostratigraphic unit. 2) TSS5 is a regional layer of basaltic flows deposited during the late Cretaceous (ca 65 Ma). It is characterized by dimmed and chaotic reflectors. This tectonosequence overlies pre-existing Cretaceous sequences corresponding to TSS6 in the HB and UNR. 3) TSS4 corresponds to the interval between the late Cretaceous crystalline basement (ca 65 Ma) to the Late Paleocene. Pelagic and hemipelagic sediments with continuous reflectors with low amplitude are deposited along half grabens formed by the extension of the HB, UNR, and LNR. 4) TSS3 identified between the Late Paleocene and the Late Eocene is marked at the top by a regional unconformity. The unconformity was caused by local uplifting in the HB and the UNR while in the LNR and CB was due to sea level changes. 5) TSS2 identified between the Late Eocene to the middle Miocene is characterized by the tectonic extension of the HB and NR. Semi parallel reflections with amplitude and frequency variable and bounded by faulted blocks are recognized by truncation of it against seamounts and basement highs. 6) TSS1 corresponds to the Middle Miocene to the Pleistocene. This tectonosequence is bounded at the base by scattered erosional surfaces in the UNR and LNR. Carbonate build ups and pinnacle reefs grow up from the base of the middle Miocene to the early Pleistocene.

Influence of Mio-Pliocene Milankovitch Frequency Monsoon Fluctuation on Environmental Hydrology in Zhada Basin, SW Tibet

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The strength of the Indian Summer Monsoon is a primary control on environmental conditions on the high-elevation Tibetan Plateau in the Pleistocene–Holocene. Input of solar radiation, insolation, influences the amount of moisture carried by the monsoon and the distance that monsoon circulation penetrates onto the plateau, with periods of strong monsoon circulation corresponding to lake and wetland expansion on the plateau. In the SW Tibetan Plateau, the Miocene–Pleistocene Zhada Basin is at the modern boundary between the wet, southern Indian Summer Monsoon air masses and the drier Westerly air masses. Hence paleo-Lake Zhada may uniquely record strengthening and weakening of the Indian Summer Monsoon and provide insight into short-term and long-term monsoon intensity in the Mio-Pliocene via evidence of expansion and contraction of the lake.

Grain size analysis of sediment deposited in the lower ~640m of the Zhada formation yields a record of lake/wetland expansion and contraction, the basin-center transport energy, and has implications on the driving mechanisms of high-elevation monsoon intensity. We used a CILAS 1190 Laser Particle Size Analyzer to obtain the grain size distribution of sediments from 4–2500 μm. A low resolution data set, analyzed at 2 m (20 kyr) intervals, showed distinct changes in mean grain size that indicated wetland expansion at ~6.2 Ma and wetland contraction at ~3.52 Ma. Signals corresponding to Milankovitch frequencies were also observed weakly in the low-resolution data set, but required a higher resolution dataset in order to confidently constrain these signals. We increased the sampling resolution to 0.5 m (~5 kyr) intervals and report the results of grain-size analysis of this high-resolution sample set focused on the major environmental and climate transitions observed in the Zhada formation at ~3.37 Ma to ~2.26 Ma and ~8.72 Ma to ~6.15 Ma.

IMPACTOGEN TECTONIC ORIGIN FOR FORMATION OF THE PERMIAN BASIN OF WEST TEXAS AND NEW MEXICO

Alexander Cheney

Late Paleozoic assembly of the Pangean supercontinent in the western USA occurred as a result of a continental collision between North and South America. This deformational event, called the Appalachian-Ouachita-Marathon orogeny, deformed a broad area of the western USA as a result of far-field, compressional reactivation of preexisting zones of weakness in the underlying continental crust. The pre-collisional predecessor of the Permian basin, the Tobosa basin, covered an area of 222,000 km2 north of the suture between North and South America in the area of the Marathon fold-thrust belt. In this study, I examine the type of the eastern and western bounding fault systems of the Central Basin Platform and their controls by the underlying Grenville age basement structures. These faults strike nearly perpendicular to the direction of Paleozoic plate convergence known from previous structural studies. Previous geologic cross sections, and well subsidence show that these faults are normal faults controlling asymmetrical wedges of clastic sediment deposited in two rift paleoenvironments with periods of maximum extension occurring during the main pulses of collision from late Mississippian to early Permian (330-265 Ma). I conclude that the main phase of basin formation of the Permian basin in the area flanking the Central Basin platform occurred in an “impactogen” rift setting where the direction of extension is at right angles to the plate convergence direction.

CO_2 Variability from Satellite Retrievals and Model Simulations, and Possible CO_2 and CH_4 Correlations

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Abstract

Recent human activity has increased the concentration of carbon dioxide in Earth's atmosphere, which plays a major role in climate change. Satellite retrieved CO_2 measurements from Greenhouse gases Observing SATellite (GOSAT), Atmospheric Infrared Sounder (AIRS), and Tropospheric Emissions Spectrometer (TES), along with in situ measurements from the Earth System Research Laboratory (NOAA-ESRL) were used to study the variability of concentrations of CO_2 at different altitudes. A multiple regression method was used to calculate the annual and semiannual cycle of carbon dioxide. The CO_2 annual cycle and semiannual cycle amplitudes for GOSAT X_{CO2} and TCCON X_{CO2} are consistent, but smaller than those seen in the NOAA-ESRL surface data. The CO_2 annual and semiannual cycles are smallest in the AIRS mid-tropospheric CO_2 compared with other data sets in the northern hemisphere.

Similar regression analysis is applied to the Model for OZone And Related chemical Tracers-2 (MOZART-2) and CarbonTracker model CO_2. The convolved model CO_2 annual cycle and semiannual cycle amplitudes are similar to those from the satellite CO_2 retrievals, although the model tends to underestimate the CO_2 annual cycle amplitudes in the northern hemisphere mid-latitudes and underestimate the CO_2 semi-annual cycle amplitudes in the high latitudes.

AIRS mid-tropospheric CO_2 data are also used to explore the variability of CO_2 over the South Atlantic Ocean. Results obtained from this study demonstrate the strong modulation of large-scale circulation on the mid-tropospheric CO_2, and suggest that mid-tropospheric CO_2 measurements can be used as an innovative observational constraint on the simulation of large-scale circulations in climate models. Further work to study the correlation between X_{CH4} and X_{CO2} may show the tight correlation that implies there are not substantial differences in emission ratio of the two greenhouse gases during the measurement period. However, if X_{CO2} and X_{CH4} are poorly correlated, their emission ratios vary largely over time, assuming the correlation is emissions driven.

Identifying active faults in Jamaica from remote sensing, GPS, earthquake, and seismic reflection data

Sarah Dailey

The Caribbean island of Jamaica is approximately 11,500 km^2 and rises over 2.2 km above sea level at the northern Caribbean plate boundary zone. The island is uplifted on a restraining bend on the E-W trending, left-lateral Enriquillo-Plantain Garden strike-slip fault zone, and forms a paired bend with the western Jamaican releasing bend located 125 km offshore to the west of the island. Previous workers have identified three E-W trending, active or inactive, bypass fault zones in Jamaica that include the 1) Duanvale fault zone in the north part of the island; 2) Rio Minho-Crawle River fault zone along the center part of the island; and 3) South Coast fault zone. This study combines remote sensing techniques using a 15 meter DEM and a newly georeferenced geologic map of Jamaica at a scale of 1:250,0000 with previously published outcrop, GPS, earthquake, and offshore seismic reflection data to explain the regional fault patterns and active fault kinematics in this interplate setting. We propose that the Rio Minho-Crawle River fault zone is presently active and accommodates E-W interplate motion between the Gonave microplate and the Caribbean plate, while E-W shortening is accommodated by NNW-striking reverse faults that bound NNW-trending Late Cretaceous to Paleocene rifts in western Jamaica. These results are supported by a broad, diffuse zone of deformation observed in 2D seismic reflection data off the west coast of Jamaica.

Modeled impacts of relative humidity on HONO chemistry

Lijun Diao, Yunsoo Choi, Beata Czader, Xiangshan Li

Abstract

Nitrous acid (HONO) is an important source of hydroxyl radical (OH) that plays a crucial role in oxidation of volatile organic compounds (VOCs) leading to the formation of ozone. Accurate estimation of HONO in air quality modeling is important as it affects predictions of HO_x as well as ozone concentrations.

Current air quality models takes into account several HONO sources including heterogeneous formation from NO_2, but do not account for dependence of this process on humidity, where higher formation is expected with higher humidity. This dependence may be of great importance in the Houston area that is characterized by high humidity, especially in the summer months.

We propose to implement humidity dependence of heterogeneous HONO formation in air quality model. Preliminary CMAQ model simulation results show improvements on HONO predictions for the period of the Deriving Information on Surface Conditions from Column and Vertically Resolved Observations Relevant to Air Quality (DISCOVER-AQ) field campaign in September 2013.

Mauritania, northwest Africa, and the southeast coast of the USA as an asymmetrical conjugate margin

Naila Dowla

Northwest Africa, and its conjugate margin, the Eastern US, underwent petroleum exploration in the 1970s and 1980s. After a 30 year hiatus, exploration efforts have recently jump started back up in these areas. In order to better understand hydrocarbon potential in these areas, it is necessary to understand the rifting relationship between these margins. The main characteristics of offshore North Africa are defined by Jurassic age rifting from the eastern United States, Miocene volcanics and Pleistocene massive debris flows and underwater canyons. The conjugate margin, the eastern United States, is defined by its Jurassic aged rifting, broad continental shelves and present day carbonate reefs. Using seismic reflection profiles, and DSDP/IOPD well data, I established that these margins are asymmetrical. Further delving into data, I compared the two asymmetric margins to establish a hanging wall / foot wall relationship. The US east coast has a much wider continental shelf, laterally extending about 100 to 250 km out, in comparison to the shelf off of Mauritania, which extends about 70 to 100 km off the coast. A comparison of topography data shows that the Mauritanian coast exhibits steep continental shelf edge slopes, interrupted by Miocene volcanics, potentially caused by crustal thinning and mantle upwelling. The over-steepened slopes may have caused mass debris flows found throughout the region, obscuring the actual slope angle of the Mauritanian shelf. Seismic data shows no evidence for traditional passive fold belt deformation overlying a thick continuous lubricating layer on either margin. Based on the lateral extent of the continental shelves, and the presence of volcanics, the Mauritanian coast is the hanging wall in this asymmetric rifting margin. Given the asymmetric nature of the north Atlantic rift margin, hydrocarbon potential on one side of the margin will not mimic hydrocarbon potential on its conjugate.

Dredging Peridotites from Izu-Bonin-Mariana Forearc: A Cruise Report

Author: Tithi Ghosh, Jonathan E. Snow

Plate tectonics molds the structure of the earth and regulates major geological processes, driven by subduction of oceanic lithosphere. One of the major questions posed by models of the subduction process is, subduction initiation and the evolution of mantle wedge in subduction zones. Among the very few places for studying deeply submerged forearcs, the Izu-Bonin-Mariana (IBM) arc is considered to be a good example of an intra-oceanic subduction zone. 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 initiation of subduction was associated with rifting and that is evident from the presence of sheeted dykes. The inner trench wall of the forearc has preserved the entire igneous sequence formed as the Pacific plate started to plunge into the mantle.

Peridotite samples were collected on cruise KH-14-05 of the Japanese Research Vessel Hakuhomaru, by dredging from the landward slope of the forearc in northern Mariana and Izu areas. The dredging area in Mariana arc was divided into two sites; the first one was between 21.5- 23°N latitude and the second one was between 19.5-21°N latitude. The first one was chosen expecting that this area will have the older basement of West Philippine basin sea plate compared to the second area. This area was away from the spreading center when the extension ceased. The other one will have a younger basement because this area was closer to the spreading center of the West Philippine basin when the extension came to an end. The peridotites were present at a depth ranging from 5229 m to 7590 m below sea-level and were highly deformed and altered. Very few of them had original texture and mineral composition. They were mostly converted into serpentinite due to high water influx. The peridotites were mainly altered Harzburgite and Dunite. As forearc peridotites are very rare and sampling process is difficult, this finding is a remarkable addition to the study of forearc peridotites.

Structural Framework and Hydrocarbon Prospectivity of the Tobago Forearc basin-Barbados Accretionary Prism Transition Zone

Shenelle Gomez

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This study utilizes 10,000 km of modern, high-resolution, deep penetration 2D seismic data provided by the oil industry to define the structural framework and hydrocarbon prospectivity of the Lesser Antilles subduction zone in the Barbados and Trinidad maritime zones which includes the following tectonic and basinal components: 1) Paleogene Tobago basin, formed as a forearc basin in front of the Lesser Antilles volcanic arc; 2) Barbados submarine ridge and island of Barbados, that represents the Eocene Barbados prism accreted to the front of the Lesser Antilles volcanic arc; and 3) the Late Miocene Inner Forearc Deformation Belt (IFDB), a 50-70-km-wide zone of westward-verging folds and thrusts that formed as a result of ongoing convergence between the Tobago Basin and Barbados Ridge. Limited production of oil and gas on the island of Barbados confirms the presence of a working petroleum system consisting of continentally-derived, quartz-rich turbiditic sandstone reservoir of the Eocene Scotland Formation; and the subsurface presence of both Tertiary terrigenous (Type III) and possibly Cretaceous marine (Type II) source rocks. We focus our study on a 400-km-long and 50-70-km-wide fold-thrust belt, the Inner Forearc Deformation Belt (IFDB), that thrusts the western edge of the Barbados Ridge westward over the east-dipping basement of the Tobago basin. At 11.75N near Tobago, the IFDB abruptly ends where it is erosionally truncated. Thick-skinned fold and thrust structures derived from mild inversion of normal faults are observed deforming the western edge of the Paleocene-Miocene fill of the Tobago basin. Thick-skinned structures with shale diapirs are observed to the east along the edge of the Barbados ridge.

Grain Shape Analysis

Vanessa Alejandro

Morpheo is a matlab code that analyzes grain shape using Fourier analysis. A roughness coefficient is produced as the final result for roughness of a grain. Morpheo is then used to track diatoms and clay particles to exclude them from the analysis. This will also give the user a percentage of how much diatoms are present in the analysis.

Effect of slab dip versus plateau subduction on overriding plate deformation in Alaska

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Properties of subducting slabs have first order control on the surface deformation of overriding plates. By modeling a subduction zone using a realistic, modern slab configuration, an understanding of the mechanisms that are involved in, and that drive, upper plate deformation can be better understood. Deformation in south-central Alaska can be explained using a realistic flat-slab geometry, however the extent of surface deformation caused by flat-slab subduction alone versus plateau subduction is not well established. Questions regarding far field surface deformation, plate coupling, and forearc sliver processes will be addressed with 3D geodynamic models of the Alaska subduction zone in order to explore the role that the subducting Yakutat plateau plays in Alaska's deformation. 2D models will first be used in order to isolate the effects that slab dip and plate coupling have on the dynamic topography of the upper plate from that produced by the subduction of a positively buoyant plateau. Discussion of future work looking at slab dip and coupling are presented along with Yakutat plateau constraints, which will be confirmed using gravity modeling and then incorporated into 2D and 3D geodynamic models.

Elastic properties of 3D-printed physical models: Fluid substitution observations in cracked media

Long Huang, Nikolay Dyaur, and Robert R. Stewart, University of Houston

New 3D printing techniques using different materials and structures, provide opportunities to understand porous or fractured materials and fluid effects on their elastic properties. We use a 3D printer (Stratasys Dimension SST 768) to print one ‘solid’ cube model and another cube model with penny-shaped cracks. The printing material is ABS thermoplastic with a density of 1.04 g/cc, a P-wave velocity of 2179 m/s and a shear-wave velocity of 887 m/s. The solid cube has porosity of about 4%. We use ultrasonic transducers (500 kHz) to measure both P- and shear-wave velocities. P-wave velocity of the solid cube ranges from 1941 to 1952 m/s in the bedding plane. The velocity of the fast shear-wave traveling in the bedding plane ranges from 898 m/s to 901 m/s and the slow shear-wave velocity ranges from 849 m/s to 853 m/s. In the direction normal to bedding plane, the P-wave velocity is about 1835 m/s and shear-waves ranges from 839 m/s to 843m/s. The cracked model, gives a density of 0.79 g/cc and a porosity of about 24%. This model is closer to VTI symmetry with a P-wave velocity of 1438 m/s parallel to symmetry direction and 1638 m/s in the bedding plane. The fast and slow S-wave velocities are 825 m/s and 665 m/s respectively. Q factors for P- and S-waves in different directions are also estimated using spectral ratio method and we observe QP ranges from 14.9 to 16.7 and QS ranges from 23.8 to 29.9 assuming a VTI symmetry. A fluid substitution experiment is performed and an increase (26% to 38%) in P-wave velocities and a decrease (4% to 10%) in S-wave velocities are observed. 3D printed material has promising properties for seismic physical modeling which may vary depending on goal of scientific research.

Fault Trend in Bakken Formation

Ismot Jahan, John Castagna
University of Hounton

The Middle Bakken Formation in the Williston Basin is fractured in horizontal direction which is observed from the shear wave splitting in the lateral well. Different fault attributes has been generated from 3D seismic P-wave data for Bakken formation. Comparison between different fault detection techniques like coherency, curvature, dip, phase discontinuities, APCA (FaultDetect) on this survey shows different fault patterns which is related to the basin generation and stress history. The fault pattern observed in this basin may be related to the production of the oil and gas in Bakken formation.

Investigation of Atmospheric Moisture Recycling Rate from Observations and Models

Angela Kao[1], Xun Jiang[1], Liming Li[1], James H. Trammell[1], Guang J. Zhang[2], Hui Su[3], and Yuk L. Yung[4]

Precipitation and column water vapor data from 13 CMIP5 models and two observational datasets (SSM/I and GPCP) are used to analyze atmospheric moisture recycling rate from 1988 to 2008. The comparisons between the observations and model simulations suggest that most CMIP5 models can capture two main characteristics of recycling rate: (1) long-term decreasing trend of global-average oceanic recycling rate and (2) dominant spatial patterns of the temporal variations of recycling rate (i.e., increasing in Intertropical Convergence Zone and decreasing in sub-tropical region). All models except one successfully simulate not only the long-term trend but also inter-annual variability of column water vapor. The simulations of precipitation are relatively poor especially over the relatively short time scales, which lead to the discrepancy of recycling rate between the observations and the CMIP5 models. Comparisons of spatial patterns also suggest that the CMIP5 models simulate column water vapor better than precipitation. Our comparative studies indicate scope for improvements in the simulations of precipitation especially for the relatively short time-scale variations to better simulate the recycling rate of atmospheric moisture, an important indicator of climate change.

ANALYSIS OF CRETACEOUS EDWARDS FORMATION USING INTEGRATED REMOTE SENSING TECHNIQUES

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It is estimated that about half of the world's hydrocarbon reserves are held in carbonate formations. By investigating the properties of reservoir analogs, knowledge is gained which could aid hydrocarbon exploration. Rudist buildups are known to produce hydrocarbons in the Middle East, Mexico, and United States. The Cretaceous Edwards formation contains rudist reef mound deposits which are exposed in the Lake Georgetown Spillway. Several methods are being utilized to model the structure and composition of these buildups in central Texas. Specim ground-based hyperspectral camera system with visible near infrared and short wave infrared sensors is used to quantify the chemical composition of exposed rock. Petrographic study of samples from this area is used to estimate relative mineral abundances and provides a ground truth for remote sensing data. Terrestrial LiDAR data is used to spatially correct hyperspectral imagery, and Ground Penetrating Radar allows visualization of lithological layering at depth. This ongoing research involves integration of these datasets to analyze properties of this carbonate formation and creating a model which could be applicable in other regions.

Influence of basement dip on morphological and structural characteristics of the Perdido-Port Isabel and Northern and Southern Mexican Ridges, western Gulf of Mexico

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Passive margin foldbelts extend across the US-Mexico maritime zones in the Gulf of Mexico (GOM) and form an important habitat for recent deepwater oil discoveries over the past decade. The semi-continuous, 340-km-long, composite US-Mexico passive margin foldbelt is bathymetrically-expressed in water depths of 1400-2300 m and consists of three, arcuate thrust salients based on a compilation of 1900 km of seismic and well data combined with GIS layers of maps and cross sections from previous workers in the US and Mexico GOM. The salt-cored, 265-km-long Perdido-Port Isabel (PPI) foldbelt salient consists of a normally-faulted updip area that is 494 km wide and a downdip fold and thrust area that is 165 km wide. A sharp recess separates the PPI from the 245-km-long shale-cored and arcuate Northern Mexican Ridges (NMR) to the south with a normally-faulted up dip area that is 62 km wide and down dip thrust area that is 200 km wide. Another sharp recess separates the NMR from the 330-km-long, shale-cored and arcuate Southern Mexican Ridges. I have calculated the regional dip angles underlying the PPI (2-5 degrees), known to be salt-cored; the NMR (1-2 degrees) and SMR (1-2 degrees), both known to be shale-cored. The PPI is the most complex as its basal surface does not dip uniformly seaward towards the Gulf of Mexico. Instead, the surface dips seaward beneath the coast of Texas but then dips landward as part of a basement high, before resuming an average dip beneath the Perdido foldbelt. Basement dips of the NMR and SMR show simpler uniform dips to the Gulf of Mexico. I conclude that the longer runout of the NMR than the SMR is likely related to its steeper dips and its having a more uniform basement compared to the PPI.

Pamir intra-continental overlapped subduction and anataxis: evidence from Cenozoic UHT metamorphic xenoliths and ultrapotassic volcanic rock

Li Yipeng Joel Saylor Dinglin Alexander Robinson

The ultrahigh temperature eclogite, granulite and pyroxenite xenoliths erupted in an ultrapotassic volcanic pipe at 11Ma in the Southeastern Pamir syntaxis record the thermal condition, composition, and architecture from lower crust to upper mantle depth beneath the Pamir. The metamorphic phase equilibria pseudo-sections combining with thermo-barometers indicate that the P-T conditions are 1240C at 18.5kbar in the mafic granulite xenolith, 1330C at 28.5kbar in the felsic (metapelite) granulite xenolith, 1375C at 38-39kbar in the two felsic eclogite xenoliths, 1420C at 41kbar in the mafic eclogite xenolith, and 1200-1400C at 57-60kbar in the phlogopite-pyroxenite respectively as the metamorphic peaks, and 1482-1534C at 62-70kbar in the ultrapotassic volcanic rocks as the anatexis. These P-T conditions represent the thermal gradients changing from 20.3C/km to 6.6C/km at the depth between 62km and 200km beneath the Pamir. The similar incompatible elements patterns between felsic granulite (metapelite), mafic eclogite, pyroxenite and ultrapotassic volcanic rocks implicate their petro-genetic relationships. The K-feldspar gradually consuming from the felsic granulite, mafic eclogite to the pyroxenite coincide with the phlogopite growth in the thin-sections is consistent with the K-feldspar melting reactions in the pseudosections. The concordant age spectra from metamorphic zircon U-Pb dating indicates that the unified ages of the metamorphic peaks in these xenoliths span from 30 Ma to 11 Ma and are concentrated at 20 Ma. The provenance analysis incorporating zircon age spectra and Sr-Nd isotope indicates that the mafic granulite xenolith at 62km depth shows Mazar affinity, the felsic granulite (metapelite) xenolith at 95km depth shows Kunlun affinity, the felsic and mafic eclogite xenoliths at 127-135km depth show Ladakh affinity, the pyroxenite xenolith at 200km is directly from metasomatized lithosphere mantle. Therefore, we suggest that the terranes inside the Pamir experienced intra-continental deep subduction during 30-11Ma, and overlapped each other under different subducting depth before eruption; the subduction accompanied with extensive potassic enriched anatexis which is mainly contributed by the K-feldspar dry partial melting during prograde metamorphism.

GLOBAL GEOCHEMICAL SIGNATURES OF K-RICH MID-OCEAN RIDGE BASALT

Xiang Ling, Jonathan E. Snow

Mid-ocean ridge basalts (MORB) and ocean island basalts (OIB) provide a window to show the chemical and isotopic trends caused by processes of melting, evolution and mixing melts of different mantle sources. An unusual kind K-enriched mid-ocean ridge basalt was first observed on the Southwest Indian Ridge, and then on the Lena Trough in the Arctic Ocean. These basalts have an unusual chemistry that is different from other enriched MORB and OIB (higher SiO_2, Al_2O_3, K_2O, K_2O/TiO_2 ratio, lower FeO, Zr/Nb, Y/Nb). Results from the geochemical investigation of those basalts suggest that some other enriched MORB could also have a similar high K/Ti ratio.

This study addresses the influence of the potassium rich source (e.g. garnet bearing peridotite) on mid-ocean ridge basalt chemistry through modeling and comparing major element data of MORBs at localities including Southwest Indian Ridge (Narrowgate Segment) and central Lena Trough with the experimental results which was conducted at 3GPa near solidus of garnet peridotite involving producing basalts with changing concentrations of added K_2O, and with the composition (olivine, orthopyroxene, clinopyroxene, and garnet) similar to fertile upper mantle peridotites. Local- scale studies of basalts along the Gakkel Ridge and Southwest Indian Ridge shed light on the MORB at ultraslow-spreading ridges. A series of forward model melt trajectories are modeled to explore the means by which our measured Gakkel Ridge Basalt data (especially Lena basalts) could be generated by mantle melting processes. The data from this study is compared with other MORB data in a global scope involving a compiled K-enriched ridge basalt geochemical database. A better understanding of the chemical diversity of the enriched MORBs can lead to better understandings of ridge evolution as well as the global MORB diversity and the inferences on the nature of their mantle sources.

Controls of asymmetrical rifting on distribution and thickness of pre-salt carbonate reservoirs in sag basins of Brazil and West Africa

Patrick Loureiro

We explain the asymmetrical distribution and thickness variations in the areas of, pre-salt carbonate sag basins in Brazil and West Africa by first, isostatically correcting the top of oceanic crust in the area of the Santos to Espirto basins of Brazil and their conjugates in the Namibe and Kwanza basins of Namibia and Angola to improve the mapping of the continent-ocean boundaries in these areas, and second using bathymetric, gravity, magnetic and 1,700 km of regional seismic transects to define asymmetrical rift margins in both areas. For the Santos-Namibe conjugate, we propose Santos to be the hanging wall of an asymmetrical rift system with a 200-km-wide rifted margin and overlying sag basin with carbonate reservoir facies and sloping bathymetric profile and the Namibe to be the footwall with a 125-km-wide rift and sag basin and steeper bathymetric profile. For the Campos-Kwanza conjugate, we propose Campos to be the footwall with a 150-km-wide rift zone and overlying sag basin and sloping bathymetric profile. Well data from sag and associated overlying salt basins shows that thicker sag (135- 325 m) and overlying salt basins (up to 2,000 m) are associated with the hanging wall blocks of Kwanza and Santos and thinner sag (15-75 m) and overlying salt basins (up to 1,500 m) are associated with the footwall blocks in accord with predictions based on analog modeling. Reservoirs within the sag phase of these conjugate margins include high porosity and permeability lacustrine carbonates (high-energy ooid and oncoid beds along with highly porous travertine hot-spring deposits that include very porous tufa mounds) overlain by over 1 km of evaporates. These reservoirs are sourced by lacustrine source rocks found on both sides of the conjugate margin between Brazil and West Africa, and which Schiefelbein et al. (2000) found to be genetically related and deposited in brackish-saline lacustrine environments created during the syn-rift phase. Based on these correlations we predict more potential in thicker sags associated with hanging wall-related sag basins of Santos and Kwanza.

CARBON ISOTOPES OF EVOLVED CO_2 DURING ACETIC ACID OXIDATION BY DIFFERENT OXIDIZING AGENTS.

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Introduction: The presence of organic material has long been a speculation on the surface of Mars. The reason for there being no positive identification has been attributed to the presence of oxidizing agents in the martian atmosphere and soil.

A variety of oxidizing agents can be generated under martian surface conditions, such as H_2O_2, hydroxyl radical ($^{\cdot}OH$), and perchlorates.

Oxidation of organic matter can proceed through a series of pathways under different conditions.

Experiments: The Finnigan GasBench II and Thermo MAT IRMS was used as the experiment platform.The average uncertainty of the $\delta^{13}C$ is ± 0.5‰.

In each experiment, 0.1 ml of hydrogen peroxide or magnesium perchlorate (1 M) is used as the oxidizing agent, and placed in 12 ml vials with septum caps. After flushing the vials with He, acetic acid is injected through the septum. Carbon isotope measurement of CO_2 is performed after 2, 4, 24, 48, 72, and 120 hours. The temperature was set at 30 ^{o}C.

Results and Discussions: The results indicated that the CO_2 abundance is always higher in experiments with the presence of Ni-magnetite.

The value becomes depleted in ^{13}C for the first 75 hours, from -31.3‰ to -33.0‰, and then enriched (-28.7‰). With the presence of Ni-Magnetite, however, the $\delta^{13}C$ value of CO_2 was higher than that of acetic acid. In the first 75 hours, the $\delta^{13}C$ value of CO_2 decreases from -4.3‰ to -7.5‰, and was constant at that value for the rest of the experiment.

Theoretical isotope equilibrium prediction indicated that the fractionation between CO_2 and acetic acid at 30 ^{o}C is about 9.5‰. Our experimental results showed that the fractionation between CO_2 and acetic acid was negative in H_2O_2 experiments without Ni-magnetite, whereas positive with Ni-magnetite. CO_2 were not in ^{13}C equilibrium with acetic acid after 120 hours, suggesting kinetic-driven processes during oxidation.

The higher $\delta^{13}C$ values of CO_2 in the experiment with the presence of Ni-magnetite may be attributed to the different reaction pathway involved in oxidation processes.

Conclusions: Carbon isotope measurement of CO_2 evolved from acetic acid oxidation experiments suggested that organic intermediates and reaction pathways may be different with different oxidizng agents, which control the isotope values of CO_2 and other organic compounds. Considering the high oxidation state in martian atmosphere and upper subsurface, assessment of controlling factors associated with organic oxidation may be instrumental in understanding the history of carbon-bearing compounds on Mars.

Effect of sea level changes on the landbridges connecting Hispaniola, Puerto Rico and the US Virgin islands during the height of the Last Glacial Maximum (26500-19000 Ka)

Sabrina Martinez

During the Last Glacial Maximum, a period from 26500-19000 Ka, ice sheets covered most of North America, Greenland and northern Europe. These ice sheets affected the climate which caused drought, desertification and a pronounced drop in eustatic sea levels of approximately 125-135 km. This lowering in sea level allowed for the emergence of “land bridges” that are now below sea level. Using eustatic sea level curves (Clark et al 2009), NOAA bathymetry and Midland Valley’s move software (2014.2), I have created a 3D visualization of the islands and identified paleoshorelines as well as creating a 2D map in ArcGIS revealing the length and width of land bridges connecting the islands of Hispaniola, Puerto Rico and the virgin islands. I have identified approximately 5 land bridges that connect several of the islands, ranging in lengths from 15 to 35 km. The identification of these land bridges, tied to Eustatic sea level changes, have helped constrain the paleogeography of the islands and provide insight into possible paleo migration routes.

Anisotropic effective medium modeling to microstructural properties of gas shale

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Elastic properties are important to link seismic properties with reservoir properties of a rock. The effective elastic properties are the combined response of elastic response of individual components of a rock such as matrix minerals, porosity, pore shape, pore connectivity and density. We used GSA (General Singular Approximation) effective medium theory to model effective stiffness of Barnett Shale utilizing mineral composition data from XRD (X-Ray Diffraction) measurements. To confirm the validity our model and results we invert the lab measured directional seismic velocities to microstructure and reservoir properties and compare outputs.

Seismic-Style Processing of Numerical EM Data

John W. Neese

Standard seismic processing methods are applied to numerical simulations for several variations of a standard 1-D numerical CSEM model, calculated using seismic-style acquisition parameters: an impulsive source and many receivers, unaliased. The data are normalized to unit maximum amplitude at each offset, making the weak far-offset signal visible (seismic-style) without computation of apparent resistivity (EM-style). Hence the amplitudes are not appropriate for inversion (EM-style), but the moveout is interpretable (seismic-style) for the presence of a reservoir layer.

Plots of normalized data exhibit distinctive moveout, similar to seismic data, but with significant dispersion. The dominant moveout is shown to be linear at a given frequency, consistent with theoretical expectation for lateral (head) waves. Conventional (semblance) velocity analyses and stacking detects a 100 Ωm reservoir on the basis of its linear moveout, but does not appear to be useful for picking stacking velocities. Linear Radon transforms also detect the reservoir.

Standard seismic processing methods are modified to account for the strong frequency-dependence of the EM data, in order to focus on the resistivity. Moveout as a function of frequency is replaced by moveout as a function of resistivity. A resistivity moveout correction is defined that indicates the existence of the reservoir, and estimates its effective resistivity. Similarly, a modified Radon transform ("EM-Radon") is defined which also indicates reservoir existence and effective resistivity.

These calculations demonstrate that, in simple cases, numerical CSEM data, appropriately acquired, and processed seismic-style, can be interpreted for subsurface effective resistivity.

Scanning Electron Microscopy and Energy Dispersive Spectroscopy Analyses of Muong-Nong Type Tektites from Hainan Island, China

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Tektites from the Australasian strewnfield in Hainan Island, China were examined to isolate relict inclusions of fine terrestrial sediment. If discovered, trace elemental analyses of the sedimentary inclusions could potentially aid in determining the tektite's origin and impact site(s). The tektite was sliced into ~3mm thick slabs and a visual inspection yielded several potential locations for analyses that appeared to be different in composition from the surrounding dark tektite. These sites were examined in a scanning electron microscope (SEM) to confirm the presence of terrestrial sedimentary inclusions within the glassy matrix. SEM analyses were performed using relatively low beam energy (10K-15K volts), in a high pressure (~60 Pascal's) vacuum chamber environment. The SEM was outfitted with an Energy dispersive spectrometer (EDS) system with a light element detector that can measure x-rays from all elements heavier than beryllium. Initial SEM examination was performed with a backscatter electron detector which shows elemental density contrasts as distinct 'gray-levels' aiding in visual differentiation of minerals. The backscatter detector coupled with the elemental data provided by the EDS system was used to investigate the composition of the potential sedimentary inclusion sites. Regions of varying grey-levels, at the potential inclusion sites, were visually detected with the backscatter detector; however no elemental differences were detected between these inclusion sites and the surrounding tektite when spectral maps were generated with the EDS system. Upon further investigation with a secondary electron detector these sites were identified as vesicles likely formed by fluid or gas escape.

REMOTE DETECTION OF FLUID-RELATED DIAGENETIC MINERALOGICAL VARIATIONS IN THE WINGATE SANDSTONE AT DIFFERENT SPATIAL AND SPECTRAL RESOLUTIONS

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Well-exposed eolian units of the Jurassic system on the Colorado Plateau including the Wingate Sandstone, show prominent color variations throughout southeastern Utah due to diagenetic changes that include precipitation and/or removal of iron oxide, clay, and carbonate cement. Spatially variable characteristic diagenetic changes suggest fluid-rock interactions through the sandstone. Distinctive spectral signatures of diagenetic minerals can be used to map diagenetic mineral variability and possibly fluid-flow pathways. The main objective of this work was to identify characteristic diagenetic minerals, and map their spatial variability from regional to outcrop scale in Wingate Sandstone exposures of Lisbon Valley, Utah. Laboratory reflectance spectroscopy analysis of the samples facilitated to identify diagnostic spectral characteristics of the common diagenetic minerals and their relative abundances between bleached and unbleached Wingate Sandstone. Comparisons of reflectance spectroscopy with satellite, airborne, and ground-based imaging spectroscopy data provided a method for mapping and evaluating spatial variations of diagenetic minerals. The Feature-oriented Principal Component Selection method was used on ASTER satellite data so as to map common mineral groups throughout the broader Wingate Sandstone exposure in the area. The Minimum Noise Fraction and Spectral Angle Mapper methods were applied on airborne HyMap and ground-based hyperspectral imaging data to identify and map mineralogical changes. The satellite and airborne data showed that out of 25.55 km^2 total exposure of Wingate Sandstone in Lisbon Valley, unbleached sandstone cover 12.55 km^2, and bleached sandstone cover 8.90 km^2 in the northwest flank and 5.09 km^2 in the southern flank of the anticline. The ground-based hyperspectral data demonstrated the ability to identify and map mineral assemblages with two dimensional lateral continuity on near-vertical rock faces. The results showed that 39.71% of the scanned outcrop is bleached while 20.60% remain unbleached. The bleached and unbleached areas are alternating throughout the vertical face of the outcrop. The relative hematite abundance observed in the unbleached areas are somewhat symmetrical towards the reaction front between bleached and unbleached areas. The distribution geometry and relative abundances of diagenetic minerals not only suggest episodes of fluid-flow in Wingate Sandstone but also provides some insight about relative direction of past fluid-flow.

MELT INCLUSION ANALYSIS OF RBT 04262 WITH RELATIONSHIP TO SHERGOTTITES AND MARS SURFACE COMPOSITIONS.

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RBT 04262 is a Martian meteorite, classified as a shergottite. To extend our understanding of RBT 04262, a study of its melt inclusions is being conducted. Melt inclusions provide a snapshot in time of the evolution of the magma from which RBT 04262 crystallized. The melt inclusions are olivine hosted and the study has been able to identify five viable melt inclusions.

Using a Cameca SX100 microprobe, the compositions of the various mineral phases of the melt inclusions was acquired. Through the use of photo-editing software, the modal abundances of the phases was determined. To compensate for the Mg-Fe exchange of the melt inclusion with the host olivine, Petrolog3 was used. This software provided the theoretical composition of the melt inclusions at the moment of entrapment.

This melt inclusion data has been plotted against the known surface data from Mars. To further elucidate the possible connections between melt inclusion data and the Martian surface, other shergottite melt inclusions were also plotted. It is clear that most of the melt inclusion data plots far from the bulk shergottites and is high in silica and alkalis, but low in magnesium, indicating a more evolved melt.

To better understand how the melt inclusions evolved, alphaMELTS (a petrological software package) is being used. While it is unknown what the conditions of crystallization were, a separate program has been written to run various conditions in alphaMELTS, iteratively. Taking known bulk shergottite compositions, this program models the crystallization of the magma. With the 70,000+ iterations of the program complete, current work is being done to filter through the data and see if there is a match to the melt inclusion compositions and provide possible conditional constraints to the Martian surface at the time of crystallization of RBT 04262.

TECTONIC CONTROLS AND TIMING OF THE INVERSION OF THE LATE JURASSIC ESPINO RIFT OF CENTRAL VENEZUELA

Lourdes G. Rodriguez

The Espino rift is a 60-100 km-wide, symmetrical, subsurface rift of Jurassic age trending to the northeast beneath central Venezuela and extends 500 km to the southwest into Colombia as the San Fernando rift. The Espino-San Fernando rift has the exact trend as the Tukutu rift of Brazil and Guyana to the southwest; both rifts reflect the breakup of western Pangea into North and South America. The Espino rift is buried by approximately 2800 m of Oligocene to Miocene clastic deposits of the Eastern Venezuelan foreland basin. The deposit is mainly composed, from top to bottom, by green to gray shales, a sequence of sandstones, limestones and shales, and interbedded sandstones and gray shales. Most of the normal faults dip to the northwest.

Seismic data show that the Espino rift experienced two, widely separated periods of tectonic inversion of its bounding, normal faults: a latest Jurassic folding and inversion event that led to an angular unconformity between the syn-rift section and overlying passive margin, and later an early Miocene inversion related to collision and strike-slip displacement of the Caribbean plate. The amount of inversion related to this younger even progressively increases from southwest to northeast and culminates in the Anaco thrust, which was one of the earliest described inverted normal faults in the literature.

STABLE ISOTOPIC RECORD OF MONSOON INTENSITY AND PALEOENVIRONMENTAL CHANGE IN THE ZHADA BASIN, SW TIBET

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Climate and environmental changes associated with strength variations of the Indian Summer Monsoon have been extensively studied at low elevations flanking the Tibetan Plateau. However, little is known about the effects of long- or short-term climate change on the plateau itself in the Neogene; existing records focus on the late Pleistocene–Holocene. In the southwestern Tibetan Plateau, monsoon-sourced moisture from the south mixes with drier Westerly air masses to the northwest. Strengthening or weakening of the monsoon will correlate to a decrease or increase in $\delta^{18}O$ values, respectively. Continuous late Miocene–Pleistocene sedimentation coupled with limited post-depositional deformation makes the Zhada basin of southwestern Tibet an ideal location to better understand paleoenvironmental evolution on the high-elevation Tibetan Plateau.

Here, we utilize stable isotopic (O and C) analysis to determine if changes in precipitation/evaporation, related to strength variations of the ISM, drove late Miocene environmental change in the Zhada basin. Both the $\delta^{18}O$ record and the depositional record indicate long-term changes in basin hydrology, potentially attributable to regional tectonics. These long-term changes are characterized by a change from fluvial/palustrine deposition to palustrine/lacustrine deposition coupled to an increase in average $\delta^{18}O$ values of bulk sediment at 6.11 Ma. This was followed by a return to palustrine/fluvial deposition and a decrease in mean $\delta^{18}O$ values at 3.24 Ma. High-frequency variations in the $\delta^{18}O$ values reflect changes in precipitation/evaporation attributable to the strengthening and weakening of the ISM. Frequency analysis reveals that Milankovitch cycles are recorded in the Zhada basin suggesting that insolation-driven climate change, rather than elevation changes, drove high-frequency environmental changes in southern Tibet. Counterintuitively, frequency analysis of the non-stationary component of the $\delta^{18}O$ record indicates strengthening in the 100 kyr (eccentricity) band; coincident with the onset of Northern Hemisphere Glaciation, but ~2.4 Myr prior to strengthening of the eccentricity band recorded in the marine record. The discrepancy between marine and high-elevation records suggests the Indian Summer Monsoon is not directly responding to the expansion and contraction of large-scale continental glaciers.

TECTONIC EVENTS IN THE WESTERN MARACAIBO BLOCK: BASED ON BASIN ANALYSIS OF THE CESAR–RANCHERIA BASIN, NORTHWESTERN SOUTH AMERICA

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The complex tectonic evolution of northwestern South America is recorded by a variety of deformed, onland basins. We assess the tectonic effects of the Caribbean–South American plate convergence on intra-plate, sedimentary, and structural processes, based on a study that includes a regional basin analysis of the Cesar–Rancheria Basin (CRB), an inter-montane basin located ca 200 km from the Caribbean subduction margin and limited by the Sierra de Santa Marta massif (SSMM) to the northwest and the Perija range (PR) to the southeast. Main purpose of this study is to contribute to the understanding of crustal structure, possibly controlled by inherited Mesozoic features, and key Late Cretaceous–Cenozoic tectonic stages driven by the South American–Caribbean plate interaction. Our observations include: (1) basement-involved high-angle faults that expose Jurassic to Early Cretaceous rocks in the CRB and Paleozoic rocks in the PR, (2) in general, faults seem to be younger toward the east of the CRB, (3) straight gravity and magnetic lineaments, (4) two major unconformities (late Miocene and late Eocene) that show significant erosive stratal truncations, (5) Changes in location of the Paleogene-Cretaceous and Neogene preserved depocenters from west to east. We interpret low values of shortening across the CRB (<10%) as consequence of the proposed high-angle, basement-involved reverse faults. Two major periods of NW–SE crustal shortening are identified: (1) an early–middle Eocene event that produced east-dipping Cretaceous and Paleocene strata and overlying major unconformity, which increased in erosional hiatus from east to west, probably associated with the collision of the Caribbean arc with South America; (2) a late Miocene–Pliocene event with major exhumation of the eastern CRB where recent deposits are faulted possibly as a result of the late Miocene to Recent Panama arc collision. The west-to-east migration of deformation during the Cenozoic also led the present-day distribution of preserved depocenters with a major thickness of the Paleocene–early Eocene section to the east and a major Miocene depocenter to the west.

Transport of industrial plumes in the Greater Houston area on the morning of November 3rd, 2009

Shelton J., Rappenglück B., Blood P., Alvarez S., Shauck M.

Sulfur dioxide (SO_2) was one of the chemical species measured by aircraft during the Study of Houston Atmospheric Radical Precursors (SHARP) field campaign. During a flight on the morning of November 3, 2009, SO_2 concentrations >30 ppbv were observed as the aircraft descended to the William P. Hobby Airport. Meteorological data revealed the highest concentration of SO_2 (35.4 ppbv) to be located within an isothermal layer at 60 m above mean sea level. Northeasterly flow as indicated by a backward trajectory originating from the location of maximum SO_2 was validated by wind data collected on board the aircraft. In agreement with the backward trajectory, we conclude that polluting sources in the Ship Channel area were the largest contributors to elevated levels of SO_2 downwind.

Tyson Smith
Joel Saylor

REVEALING THE ANCESTRAL ROCKY MOUNTAINS: STRATEGY FOR UNRAVELLING LATE PALEOZOIC INTRAPLATE DEFORMATION IN NORTH AMERICA

Intraplate strain, deformation extending 100s to 1000s of km from active margins, is a commonly recognized plate tectonic phenomenon, yet it is poorly understood. The Ancestral Rocky Mountains (ARM) are a unique example of intraplate deformation that occurred amidst the geologic turbulence of late Paleozoic North America. Defined as a series of discrete crustal uplifts and adjacent flexural basins, several characteristics assort the ARM as particularly anomalous: A) deformation >1000 km from the nearest active plate margin, B) discrete deformation separated by 100s of km of apparently undeformed crust, C) poor organization of major faults, both internally and with respect to plate margins, and D) the position of NA, and associated oceanic crust, as the down-going plate in Ouachita-Marathon (OM) subduction. The goal of this research is to evaluate the temporal spatial patterns of uplift and subsidence to develop a viable kinematic model for ARM deformation.

Two competing driving mechanisms have been offered to explain ARM tectonics. More commonly accepted is collision between Gondwana and the uneven NA plate margin (i.e. the OM orogeny). Alternatively, hypothesized shallow angled slab subduction off the SW coast of NA drove ARM deformation through basal traction with the NA lithosphere. The OM driving mechanism predicts an E to W pattern of deformation in step with the orogeny, whereas the shallow slab model predicts uplift SW to NE at the migrating edge of the shallow section or slab.

Reconstructing timing of lithospheric deformation is key in testing ARM kinematic predictions. This investigation will employ field and subsurface observation and measurement in tandem with petrochonology to assess ARM exhumation and provenance history. Laramide deformation reactivated many ARM structures, but mineral assemblages, sedimentary structures, and stratal and facies relationships of contemporaneous deposits preserve the record of ARM development. Therefore, research will focus on the clastic fans shed by major ARM uplifts: Uncompahgre (UT), Pedernal (NM), Ancestral Front Range (CO), and Amarillo-Witchita (OK). Employing this set of interdisciplinary tools, applied to regionally broad, but location specific targets is a necessary strategy to adequately investigate the enigmatic continental swath of ARM deformation.

THE LONG TERM ANALYSIS OF TROPOSPHERIC NO_2, HCHO AND SURFACE OZONE IN URBAN CITIES OF TEXAS

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Abstract. This work presents a long-term (2005-2013) analysis of tropospheric NO_2 and HCHO using the Ozone Monitoring Instrument (OMI) satellite and surface ozone using Continuous Ambient Monitoring Stations (CAMS) sites in urban cities of Texas. Rather than focusing solely on seasonal changes, we consider other harmonic changes using Least Squares Harmonic Estimation (LS-HE), which reduces uncertainty in trends by 5-15%. Annual tropospheric NO_2 observed from OMI experiences a downward trend in Austin ($-0.06\pm0.02\times10^{15}$molec./cm^{2}yr^{-1}), Dallas ($-0.21\pm0.04\times10^{15}$molec./cm^{2}yr^{-1}), Fort Worth ($-0.16\pm0.04\times10^{15}$molec./cm^{2}yr^{-1}), Houston ($-0.14\pm0.05\times10^{15}$molec./cm^{2}yr^{-1}), and San Antonio ($-0.07\pm0.02\times10^{15}$molec./cm^{2}yr^{-1}) because of their efficient emission policies while OMI HCHO exhibits both negative and positive annual trends in Austin ($+0.09\pm0.04\times10^{15}$molec./cm^{2}yr^{-1}), Dallas ($-0.01\pm0.03\times10^{15}$molec./cm^{2}yr^{-1}), Fort Worth ($-0.04\pm0.03\times10^{15}$molec./cm^{2}yr^{-1}), Houston ($-0.06\pm0.04\times10^{15}$molec./cm^{2}yr^{-1}), and San Antonio ($+0.01\pm0.02\times10^{15}$molec./cm^{2}yr^{-1}) mainly resulting from differences in decreases in anthropogenic emissions, the impact of climatic variations and biogenic emissions. The discrepancy between the annual trends of HCHO and NO_2 provides strong evidence that all of the cities gradually became more NO_x-sensitive. We obtained the slope of HCHO/NO_2 ratios (a proxy for chemical condition) from OMI for Austin (0.10±0.04 yr^{-1}), Dallas (0.08±0.03 yr^{-1}), Fort Worth (0.07±0.03 yr^{-1}), Houston (0.06±0.03 yr^{-1}), and San Antonio (0.08±0.03 yr^{-1}) and investigate the surface ozone patterns along with maximum, annual, and minimum trends in relation to changes in their precursors and prevailing chemical conditions. The surface levels of wintertime ozone measured by CAMS increase in Austin (0.90±0.53 ppbv yr^{-1}), Dallas (0.62±0.53 ppbv yr^{-1}), Fort Worth (0.59±0.40 ppbv yr^{-1}), Houston (0.56±0.55 ppbv yr^{-1}), and San Antonio (0.64±0.54 ppbv yr^{-1}) because of the reduction in the amount of ozone quenched through NO_x titration. Summertime ozone surface mixing ratio trends are mainly governed by NO_2 annual trends as well as climatic influences. We obtained the downward annual trend of the ozone mixing ratio from CAMS observations for Austin (-0.27±0.17 ppbv yr^{-1}), Dallas (-0.41±0.18 ppbv yr^{-1}), Fort Worth (-0.55±0.18 ppbv yr^{-1}), Houston (-0.53±0.18 ppbv yr^{-1}), and San Antonio (-0.03±0.16 ppbv yr^{-1}). The results show that prevailing chemical conditions control the annual trends of surface ozone. While Austin and San Antonio exhibited similar declines in NO_2 levels, a more prevailing NO_x-sensitive regime over Austin resulted in its greater sensitivity to NO_2 changes. The dominant NO_x-saturated regime over Dallas, however, led to its lower sensitivity to high annual downward trends of NO_2.

Derek Scott

Characterization of the central South Gabon Basin through 2D seismic interpretation and areas of hydrocarbon potential

Abstract

The modern equatorial West African offshore slope and deep South Atlantic basin from southern Angola to Equatorial Guinea comprises laterally extensive, and discontinuous passive margin fold and thrust belts. This deformation is the result of overburdern and subsequent deformation inducing gravity controlled sliding on the underlying Aptian-Albian salt layer. These passive margin fold-belts are poorly mapped at a regional scale yet locally form major structural traps for hydrocarbons as the Gabon Basin covers 130,300km², extends 550 km along the coast, and has recently been the location of major hydrocarbon discoveries.

Interpreting 2D seismic data courtesy of Spectrum Geo Inc. gives insight to the characterization of the offshore region of the South Gabon Basin as well as the structural styles of this particular fold belt including minibasins, half-grabens, and rollovers, as well as the types and extent of salt deformation and evacuation of diapirs, walls, and stocks which formed these tectonic structures. Interpreting regionally adjacent 2D seismic and converting to a 3D model gives insight to regional structures of interest when correlated to recent productive hydrocarbon discoveries. Creating a reconstruction of these lines gives the post Aptian-Albian kinematic evolution of the region as well as the degree of downdip shortening through thrust faulting and folding, and updip extension through normal faulting the system has undergone.

Terrestrial Laser Scanning and Hyperspectral Imaging of the Eagle Ford Formation

Lei Sun

This study use terrestrial laser scanning and ground-based hyperspectral remote sensing data to map the Eagle Ford Formation at west Texas. The Eagle Ford Formation consists of rhythmic limestone and shale with high total organic content deposited in the Cenomanian-Turonian oceanic anoxic event. Detailed remote sensing study of this formation could provide valuable geological information and foresight about hydrocarbon exploration.

Passive remote sensing has been used extensively in outcrop geology; however, the reliance on solar illumination may lead to incoherence within and between imageries due to changing illumination conditions during scanning. Active remote sensing, on the other hand, uses own energy source and is independent from the sun, so the applications are quite expanded. Terrestrial laser scanning is a novel LiDAR technique which provides fast and accurate 3D models. Besides the geometry of the objects being scanned, TLS also records the intensity of the laser returns diffusively reflected from the surface of the object. After carefully calibration, the TLS intensity data can provide insights to the properties of the objects. This study uses a Riegl VZ-400 laser scanner to scan the Eagle Ford Formation outcropped at west Texas, and extract geological information from the LiDAR point cloud.

Hyperspectral remote sensing acquires electromagnetic radiation in numerous bands in a continuous spectrum and can resolve compositions of scanned materials. Ground-based Specim dual-cameras system is used to scan the Eagle Ford Formation. The chemical composition resolved from hyperspectral data is used to validate the geological interpretations from TLS data. Spectral angle mapper is used in hyperspectral data processing, to match pixel spectra to known reference spectra in spectral libraries. Passive imagery taken with a digital camera mounted on top of the laser scanner is also used to provide three-dimensional photorealistic outcrop model.

Combining the accurate geometrical measurements and intensity records, this study builds a three-dimensional outcrop model of the Eagle Ford Formation with geological interpretations. This study explores the possibility of performing geological study using the state-to-the-art terrestrial active remote sensing, and provides a standard workflow for similar geological applications.

3D seismic facies and attribute analysis for reservoir characterization of a complex fluvial system: case study of the Late Eocene-Oligocene Carbonera Formation, Llanos foreland basin of Colombia

Author: Lucia Torrado

The Llanos foreland basin of Colombia is the country's most prolific oil producer, with most known oil fields found in anticlines bounded by normal faults. The objective of the study is to assess the reservoir potential of the Late Eocene-Oligocene Carbonera Formation, a 400-1800 m-thick tectonically-controlled fluvial reservoir unit with many potential stratigraphic traps related to unfaulted. This study integrated 700 km^2 of 3D seismic data volumes with 9 wells in the in the Central Llanos area near the Cubiro field. Attribute and acoustic impedance analysis shows that the Carbonera Formation represents fluvial deposits of straight to meandering channel belts that are seen on seismic lines as strong, high-amplitude, concave reflections with variable width to depth ratio and sinuosity. Time slices through coherence and iso-frequency amplitude cubes show 1) a meandering fluvial system with changes in the rivers' paleoflow directions from southwest to northeast, and development of tributaries systems with a northwest to southeast orientation, 2) development of prospective sandy point bars, scrolls, mid-bar and channel base deposits, 3) higher mud content in the Carbonera members 3 to 5; iv) wider channels with thicker floodplain deposits, localized sandstone bodies, higher avulsion rates in Carbonera member 5 to 3; v) fewer intra-formational seal development in the Carbonera members 1 and 7, and vi) sand-prone channels deposits in the Carbonera member 7 with high lateral migration. Thus, based on our attribute analysis along with, we were able to characterize nonprospective mud-filled channels versus prospective sand-filled channels for future exploration campaigns.

Classifying and comparing shapes of continent-ocean boundaries on the Eastern US and northwest Africa conjugate margins from interpretations of a new global gravity dataset

The continent-ocean boundary (COB) - or continent-ocean transition - is a sharp to diffuse boundary between continental crust and oceanic crust found below all passive margins. The COB is of interest for oil exploration because oil is generally not found overlying oceanic crust and therefore the COB is usually taken as the seaward limit for deep-water oil exploration. I use a new global marine gravity model from Sandwell et al. (2014) - that is two times more accurate than previous marine gravity models - to classify and compare the shapes of continent-ocean boundaries (COB) on conjugate margins of the Eastern US and Northwestern Africa. On the new gravity the continent-ocean boundary ranges from a narrow and sharp change in amplitude across the COB to a broader and poorly defined zone with no distinctive signature. I digitized the boundary over a lateral distances of about 5000 km on the conjugate margins of the Eastern US and Northwestern Africa to capture the level of detail on the satellite images and used these maps to document how the shapes of the COB's changed both along strike and between the conjugate margins. For eastern North America, the COB is forms a simple and linear boundary that coincides with the estimate of the COB by Exxon (1985) using refraction and reflection data. For the conjugate margin in northwestern Africa, the COB is not linear and instead forms a highly dentate pattern clearly affected by the terminations of oceanic fracture zones. The location of the gravity-based COB coincides locally with the Exxon (1985) estimate.

Inferring marine sediment type using chirp sonar data: Atlantis field, Gulf of Mexico

Jiannan Wang, Robert Stewart, Allied Geophysical Laboratory - University of Houston

Sediment-type profiling is important for geohazards and ma- rine geology studies. Usually this data can only be acquired by coring, which is not only expensive and time consuming, but also sparsely distributed. This paper estimates the ma- rine sediment type with a two-step procedure: First, we per- form an envelop-inversion on chirp sonar data to build the acoustic impedance profile of the sub-bottom. Unlike the seis- mic envelop-inversion, which is used mostly for building the background model from later waveform inversion, chirp sonar envelop-inversion is able to invert the impedance profile with the same resolution as chirp data itself. This is due to the na- ture of chirp sonar data compressing in the chirp processor. The field data test of the envelop-inversion agrees with the cor-ing measurement well. Then, we use empirical equations to re- trieve the marine sediment characters from inverted impedance profile. The mean grain size profile, sand percentage profile is matched with sediment type. The field data test shows the resulting pseudo-coring agrees with real coring measurement nicely. Performing this process trace by trace will give us the whole sediment type profile. All the field data in this paper is from Atlantis field, Guld of Mexico (Custody of BP Explo- ration).

Title: 2-D deformable-layer tomostatics in Sichuan, China

Author: Yukai Wo

Static correction for near-surface effects is a critical issue for onshore seismic data processing due to its significant impact on imaging the subsurface structure, especially for area with severe topographic and near-surface velocity variations. The key idea to determine static correction is to build an accurate near-surface velocity model, which leads to several methods such as refraction statics, uphole surveys and tomostatics. Among these methods, tomostatics, which builds the near-surface velocity models using tomography, is a promising method. However, in complex near-surface areas, traditional grid tomography is often unable to determine the static correction. This is mainly because the conflict between the need of smaller cell to describe the severe velocity variation and the increasing number of inversion unknowns which leads to solution's uncertainty.

The deformable-layer tomography (DLT) determines the complex near-surface velocity models by inverting for depth-varying velocity interfaces. Both synthetic and field data offer many cases illustrating DLT's effectiveness. The main advantage of DLT over grid tomography is that DLT builds a geologically reasonable model with less inversion unknowns, and can resolve the velocity model better with some constrains such as the result of uphole surveys, which is available in my study. Also, a reversed-velocity interface, which is common in mountainous area and has severe effect on near-surface imaging, may be better solved by DLT.

The survey area of my thesis is in the western Sichuan, China, which is mountainous and has a complex near-surface situation. Previous work of static correction has been done and the results of both refraction statics and grid tomostatics are not satisfactory, especially for the area with severe topographic variation. Thus, I have been motivated to find whether the DLT can be a better solution to this problem. I propose to use the DLT to build the near-surface velocity model and determine the static correction for the area. I have obtained first arrival data of 1 dipping lines in the area, plus results of uphole surveys and small refraction surveys. These results will be used to constrain the velocity model and to be compared with the DLT solution.

PROPOSAL TO QUANTIFY METHANE SOURCES (BIOGENIC VS. NON-BIOGENIC IN THE HOUSTON AREA USING $\delta^{13}C\text{-}CH_4$

Shuting Yang, Robert Talbot

Methane (CH_4) is an important greenhouse gas with its mixing ratio increasing in the global troposphere. This proposal is a timely response to the Obama administration's latest environmental regulation aiming to better monitor methane sources and leaks, and to cut CH_4 emissions on oil and gas sector over the next decades. The Houston area is the energy capital of the world, and as such has significant refining and petrochemical facilities. Fugitive CH_4 emissions from these types of sources are important but they have not been quantified. In short, Houston is an optimal place for studying CH_4 emission and sources. While concentration of CH_4 are regularly monitored, much additional information concerning CH_4 sources and leaks need be obtained through the stable isotope of carbon. So the ultimate goal of this work aims to quantify and differentiate biogenic and non-biogenic CH_4 sources in the Houston area using $\delta^{13}C\text{-}CH_4$. To achieve this goal, I will analyze CH_4 data obtained by our mobile laboratory, the NASA P3 aircraft, and selected satellites. Our group operates a mobile laboratory with two advanced Picarro cavity ring-down instruments which will quantify $\delta^{13}C\text{-}CH_4$ from different sources around the Houston area. The NASA DISCOVER-Air Quality data provides an opportunity to capture pollution plumes at elevated heights, and the middle troposphere satellite data from TES and AIRS will supply large-scale observations over my study area. This work will study plume CH_4 flux as well as leakage and distribution in the atmosphere on days with active convections. Combining surface data with plume dispersion models and back calculation method, the emission rates of CH_4 can be estimated. Overall, this proposed research aims to get a better understanding of CH_4 issue using a multi-pronged approach to quantify CH_4 sources through multi-platform observations.

SHEAR WAVE STRUCTURE IN THE LITHOSPHERE OF TEXAS FROM AMBIENT NOISE TOMOGRAPHY

Yao Yao and Aibing Li

Texas contains several distinct tectonic provinces, the Laurentia craton, the Ouachita belt, and the Gulf coastal plain. Although numerous geophysical experiments have been conducted in Texas for petroleum exploration, the lithosphere structure of Texas has not been well studied. We present here the Texas-wide shear wave structure using seismic ambient noise data recorded at 87 stations from the Transportable Array of the USArray between March 2010 and February 2011. Rayleigh wave phase velocities between pairs of stations are obtained by cross-correlating long ambient noise sequences and are used to develop phase velocity maps from 6 to 40 s. These measured phase velocities are used to construct 1-D and 3-D shear wave velocity models, which consist of four crust layers and one upper mantle layer. Shear wave velocity maps reveal a close correlation with major geological features. From the surface to 25 km depth, Positive anomalies coincide with the Laurentia craton, and negative anomalies coincide with the continental margin. The boundary of positive-negative anomaly perfectly matches the Ouachita belt. The Llano Uplift is imaged as the highest velocity through the mid-crust because the igneous rock forming the uplift has faster seismic velocity than the normal continental crust. Similarly, three small high-velocity areas exist beneath the Waco Uplift, Devils River Uplift, and Benton Uplift, even though surface geological traces are absent in these areas. The lowest velocity at the shallow crust appears in northeastern and southeastern Texas separated by the San Marcos Arch, correlating with thick sediment layers. An exceptional low velocity is imaged in southernmost Texas in the lower crust and upper mantle, probably caused by subducted wet oceanic crust before the rifting in the Gulf of Mexico. In the uppermost mantle, positive shear wave anomalies extend southeastward from the Ouachita belt to the Gulf coast, likely evidencing the subducted oceanic lithosphere during the Ouachita orogeny. This observation need be further tested using long period surface wave dispersions from earthquakes, which help to improve model resolution in the upper mantle.

Elastic properties of rock salt: Lab measurements and well log analysis in the Gulf of Mexico

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Abstract:
Seismic imaging and interpretation of regions with salt structures can be challenging. Velocity model building highly relies on the comprehensive understanding of evaporites' compositions, properties and tectonics.
We combine lab measurements and well-log data analysis to determine the compositional and elastic properties of salt crystals and rocks, especially in the Gulf of Mexico area.
We tested pure halite samples from the Goderich Mine, Ontario using ultrasonic methods and found the samples to display cubic anisotropy. Measurements for Gulf of Mexico salt samples, however, are complicated due to the compositions, micro-cracks and crystalline aggregates orientations. They appear isotopic. The velocities measured in the lab ranges from 4.43 to 4.75 km/s and 2.46 to 2.92 km/s for P and S waves, respectively. The density ranges from 2.15 to 2.18 g/cm^3.

From a study of 142 log suites of boreholes drilled through salt in the Gulf of Mexico, we find a trend of P-wave velocity V_p(km/s) increases with depth$D$(km): $V_p = 4.41 + 0.0145D$. Our fitted curve and its variation provide the reference for initial velocity models. For salt density, our electron density readings concentrate around 2.06±0.1 g/cm^3. All of these measurements assist in understanding salt and seismic velocity model building.