Salmon Glacier, British Columbia, Canada.

9th Annual Department of Geosciences Research Day Abstracts Program

May 6, 10:30-1:30, 2nd floor Science Building

TEXAS TECH UNIVERSITY
College of Arts & Sciences
Department of Geosciences

Department of Geosciences
Texas Tech University
Research Day 2015
May 6th

Welcome to the 9th Annual Department of Geosciences Research Day.

The program this year presents over 40 abstracts from faculty, graduate and undergraduate researchers covering a wide variety of topics highlighting ongoing research within the Department of Geosciences. Note 31 abstracts are first authored by geoscience undergraduates which, is on par with last year's record number of submissions. Undergraduate research within the department is a priority reflected in the volume and quality of these abstracts.

Given the current climate around oil prices, our industry presence is reduced this year. However, Steve Henderson (Halliburton) is returning to help judge the Advanced Petrophysics projects. Steve has become a regular at Research Day and we welcome him again. Additionally, we hope to have representatives from Concho Resources, Hess and Columbine Logging.

This year we have some return special presenters. Whiteface Elementary School has a 6th and 8th grade teams have advanced to a regional (US level) STEM competition. The 6th grade team is studying fracking and water quality and the 8th grade team is presenting on pollinators. We welcome them to get some practice presenting before they go compete at regionals.

The Geoscience Society is sponsoring our luncheon this year. Please thank the officers for the catered barbeque lunch. The society also provides gifts to the winning poster. Beginning last year, the society created a plaque for the top undergraduate posters. The plaque is in the second floor display case, please stop by and note past winners.

Lastly, I would like to thank all of the presenters for their hard work and commitment to providing quality research. Plus, a special thank you to all the undergraduate researchers; presenting on Research Day is one of the last hurdles you have to clear before graduation. Be proud of your accomplishments!

Let's have some fun,

Dustin Sweet

Schedule of Events
10:30-12:30 Poster Presentations
12:30-1:15 J&M Bar-B-Q Lunch
1:15 Award Presentations

*Indicates undergraduate researcher

PETROPHYSICAL EVALUATION OF THE THIRD BONE SPRINGS SANDSTONE, DELAWARE BASIN, NEW MEXICO

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Petrophysical analysis of digital well logs was applied to a section of the Permian Third Bone Springs in the Delaware Basin located in southeast New Mexico. Log data was provided for depths from 9400 to 10,000 feet, however the zone of interest was a shaly sandstone (23.8% clay), ranging from 9590 to 9920 feet deep. Log analysis was completed by carrying out petrophysical calculations including: Maturity Index (MI) [Zhou et al., 2007], Mineral Matrix Porosity (Φom), Organoporosity (Φmm), Original Oil In Place (OOIPstb), Total Organic Content (TOC), permeability (Kcmr), water saturation (Sw), mineral distribution, Poisson's Ratio (μ), and Young's Modulus (E). All calculations were done at half foot intervals. Possible producing intervals were determined by excluding depths where petrophysical values didn't meet permeability (>300nD) minimums. It is suggested that the lateral be drilled at a depth of 9760 feet. This location was selected based on the distribution of movable hydrocarbons in conjunction with our overall analysis of the zone. It is expected that multiple stages of hydraulic fractures will be completed with fracture heights that would span over 250ft in order to get the optimum productivity from the well. OOIP is calculated to be 3.2 MMstb of hydrocarbons which, using a worst case scenario 5% recovery factor will yield approximately 160,000stb of hydrocarbons. Expected drilling and completion costs are roughly $6.5MM and revenue from this interval will be approximate $9.1MM based on $57.00 per barrel oil prices. This yields net profit of $2.6 MM ($41/STB is the breakeven cost).

LATE PALEOZOIC DEVELOPMENT OF THE NORTHERN MIDLAND BASIN SHELF IN LUBBOCK AND LYNN COUNTIES, TX

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The structural development of the greater Permian Basin region can be divided into three stages. In the first stage, the Tobosa basin formed during the Cambrian through Mississippian when the region was a marine basin and collected carbonate and siliciclastic depositions. The second stage began with the Early Pennsylvanian through the Early Permian collision of the North American and South American plates during the amalgamation of Pangea. The collision caused the basin to differentiate into deep basins (the Delaware and Midland Basins segmented by the uplifted Central Basin Platform) surrounded by shallow shelves. The third stage occurred when the basin became structurally stable with clastic deposits in the deep basins and carbonate deposits on the shelves.

Fusulinid biostratigraphic and stratigraphic thickness data gathered from old wells of the 1940's to 1970's in Lubbock and Lynn counties was used to map the structural top of the Wolfcamp (lower Permian) and Strawn (mid-Desmoinesian) intervals in those counties. The structural maps demonstrate a general elevation difference of high in the northeast of the counties, to low in the southwest. This relationship is consistent with the shelf and basin delineation on published maps of the northern Midland basin. Further, the structure map of the Strawn shelf suggests a steeper gradient than the Wolfcampian shelf which may be related to high rates of shelf edge carbonate growth, coincident with basin subsidence, which restricted bypass to basin center, thereby making it deeper. Stratigraphic thickness data was further used to create an isopach map of the Strawn to Wolfcamp interval, depicting a lobate sedimentary structure with a high stratigraphic thickness relative to basin thickness, indicative of sediment influx.

A QUICK METHOD TO EVALUATE POTENTIAL "SHALE" RESERVOIRS

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In 2009 Rick Lewis with SCHLUMBERGER suggested cut-offs for Pe (< 4.0 barnes/electron) and Bulk Density (RHOb < 2.53g/cc) that can be used to define potential organic-rich "Shale" reservoirs. Walls and others (2012 & 2014) used RHOb and Pe data obtained from core [CT Scanner] to determine shale "sweet spots" in the Eagle Ford Shale.

A recent paper by Wang and Carr (2013) presented an opportunity to test these cut-offs with core derived shale lithofacies. Wang and Carr (2013) subdivided the Marcellus into the following seven lithofacies.

OSS – Organic Siliceous Shale
OMS – Organic Mixed Shale
OMD – Organic Mudstone [ductile]
GSS – Grey Siliceous Shale
GMS – Grey Mixed Shale
GMD – Grey Mudstone [ductile]
CARB – Carbonate

Along with the mineralogical analysis Wang and Carr (2013) included Pe and RHOb data for each of the seven lithofacies. A plot of their log data on a Pe versus RHOb cross plot revealed that only the best lithofacies [OSS] plotted with Pe < 4 [3.5] and RHOb < 2.53 [2.39].

Next Pe and RHOb data was obtained from two Wolfcamp wells [upper 900 feet] that in addition to Pe and RHOb data had GEOCHEM plus compressional (ITTc) and shear (ITTs) wave data. Using the ITTc and ITTs data Poisson's Ratio and Young's Modulus were calculated, and compared to the vertical distribution of zones where Pe<4 and RHOb<2.53.

The first Wolfcamp well exhibited more uniform values for Poisson's Ratio [0.2] and Young's Modulus [4.0x10^6psi] indicating more continuous good reservoir potential. The vertical distribution of zones with Pe<4 and RHOb<2.53 in this

well were numerous and more evenly distributed. In the second Wolfcamp well the lower section exhibited sharp increase in Poisson's Ratio [0.20 to 0.26], and decrease in Young's Modulus [3.6x10^6psi to 3.0x10^6psi] indicating poorer reservoir potential. In addition, the lower section in the second well contained only a very few zones with Pe<4 and RHOb <2.53. Therefore, the distribution of zones with Pe<4 and RHOb<2.53 are related to the distribution of geomechanical properties [Poisson's Ratio and Young's Modulus].

In wells with no ITTc and ITTs data the Pe versus RHOb cross plot can be used to delineate the vertical distribution of potential reservoir quality "shale". These delineated zones have a higher potential to fracture under stress [low Poisson's Ratio], and for the fractures to remain open [high Young's Modulus].

CHRONOSTRATIGRAPHIC EVOLUTION OF THE PENNSYLVANIAN-PERMIAN NORTHERN SHELF OF THE MIDLAND BASIN WITHIN HOCKLEY COUNTY TEXAS

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Late Paleozoic structure maps of biostratigraphic zone tops demonstrate the evolution of the Midland Basin shelf in Hockley County. Data utilized to construct the maps was from wells drilled from 1946 to 1973. Middle to late Pennsylvanian time slices suggest that the Pennsylvanian shelf of the Midland Basin was relatively poorly developed and was located in northern Hockley County. However, by Wolfcampian time the shelf position had prograded to southern Hockley County. The Wolfcampian shelf-slope system was steeper than the Pennsylvanian, however locally the shelf is bisected by "canyon" like features which may serve as potential sediment conduits. Previous models indicate progradation from the Pennsylvanian to Permian time frame, the results here support such a model.

3RD BONE SPRING, DELAWARE BASIN: PETROPHYSICAL WELL LOG ANALYSIS

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Petrophysical analysis of digital well logs is applied to the 3rd Bone Springs, NM log data to determine the optimum producing interval. This interval is selected with petrophysical calculations that include the following: Gamma Ray signature, Mineral Matrix Porosity, rock composition, Total Organic Content (TOC), permeability (ka), water saturation (Sw), mineral brittleness, minimum closure stress, Original Oil in Place, and Movable Hydrocarbon Index (MHI). All calculations were done at half-foot intervals and plotted to quantitatively and qualitatively choose the best producing interval. Possible producing intervals were determined by first excluding depths where there was high clay content, low permeability, low oil porosity, low brittleness coefficient, high minimum closure stress, and poor agreement with OOIP calculations. In the logs, the upper part of the 3rd Bone Spring, and slightly above the top, has the ideal geological and geomechanical properties for optimum hydrocarbon production. These include high TOC, high permeability, high oil porosity, low minimum closure stress, and high brittleness coefficient. Additionally, this upper zone has the highest OOIP, allowing for maximum recovery potential. The target is 9655ft, with the target top at 9645ft and base at 9665ft, giving a 20ft landing zone. Assuming a fracture height of 300ft that would preferentially propagate upwards, this lateral would frac 9475ft to 9775ft. OOIP from this lateral is calculated at 2,616,185 bbl which relates to 209,294 bbl at a recovery factor of 8%.

SEISMIC STRUCTURAL AND STRATIGRAPHIC ANALYSIS IN THE BRAZOS FEDERAL LEASE AREA, OFFSHORE TEXAS

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The purpose of this investigation is to characterize the stratigraphy and structure of the Cenozoic sedimentary rocks in the Brazos federal lease area located at the northwest part of the Gulf of Mexico. Twenty-three seismic reflection sections, paleontological reports from four wells and velocity survey data obtained from two wells were used to understand the development of some of Brazos growth faults. Three distinct seismic horizons with strong reflections and two major faults are picked on these seismic sections provided by CGG. To assign absolute ages to the strata seen on seismic sections, the fossil records from the study area were compared to the biostratigraphic chart of the United States Gulf Coast. The velocity survey data in the study area were used to convert the two-way travel times of the seismic sections to actual depths. The geometry of the horizons and the faults identified on these seismic sections were digitized and displayed in a 3-dimensional map in the Geographic Information System software ArcScene. The faults identified in the Brazos area are growth faults. These faults run parallel to sub-parallel to the shoreline of Texas. Despite their slight orientation difference (sub-parallel), these faults are similar to other major coast-parallel growth faults previously identified in the nearby areas.

SEISMIC MAPPING OF SEDIMENTARY STRATA AND FAULTS IN THE SOUTH MATAGORDA ISLAND AREA, GULF OF MEXICO

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A set of 14 seismic reflection sections, velocity survey data from 5 wells, and fossil records from 12 wells in the Matagorda Island federal lease area offshore Texas were examined for the purpose of understanding the stratigraphy and the faults of the area. Seismic reflection data were examined to identify the faults and reflection horizons. Velocity survey data were utilized for development of accurate velocity models to estimate depths on the seismic reflection sections. The fossil records yielded estimates of the age of the seismic horizons.

Along the northern margin of the Gulf of Mexico, many growth fault systems are present. My study area has one prominent growth fault, which is selected for detailed mapping. The geometry of 3 prominent horizons and the fault were digitized to produce their 3-dimensional models in the geographic information system software. Previous studies suggest that the growth faults in the northern region have resulted from basinward diapiric movement of over-pressured shale masses or salt masses. In my study area, shale mass movement is more likely, because the strong reflection characteristic of salt is lacking in the seismic data. The over-pressured shale masses resulted from very fast sediment accumulation that took place throughout the Cenozoic in this area. The shale mass behaved in a ductile manner and moved upward, pushing apart the overlying layers of sand resulting in the series of normal faults observed in the study area.

CHRONOSTATIGRAPHIC ANALYSIS OF IRION AND REAGAN COUNTIES, TEXAS

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The Permian Basin is among the most well-known oil fields in the world and is located in west Texas and southeastern New Mexico. The economic potential of the region has caused many to conduct research within the Permian Basin area to further understand the system as a whole. The basin was formed during the suturing of Pangea during the Pennsylvanian and Permian. This event is responsible for the creation of the Marathon Thrust Belt and associated foreland basins, the largest of which is known as the Midland Basin. The Eastern Shelf of this basin, along with the uplifted Central Basin Platform to the west of it, consists of mostly shallow reef carbonates. However, deep-water shale and sandstone deposits comprise the center portion of the basin. These siliciclastic sediments filled into low basins as subsidence occurred allowing shale and sandstone capable of containing hydrocarbons to be formed in the process.

The Midland Basin is well studied and previous paleogeographic interpretations are robust. The purpose of this study is to utilize an existing biostratigraphic database to reconstruct time intervals and compare with previous interpretations. Within Irion and Reagan counties, data was collected from original biostratigraphic reports that range in date from the 1930's to the 1970's. The reports include fusulinid biostratigraphy data as well as stratigraphic thickness data for the units observed in that well. Irion and Reagan County are located in the southeastern portion of the Midland basin. A small portion of Irion County is located on top of the Eastern Shelf. However, the majority of Irion and Reagan Counties are located within the center of the basin. The original maps created in this project will help to reinforce the positions of the Eastern Shelf as well as the distributions and depths of four chronostratigraphic units.

The four structure surfaces analyzed in this paper include the Wolfcamp, Lower Strawn, Atokan, and the Ellenberger Formation. A general trend from a higher structural position to a lower structural position can be seen towards the East in all maps produced. This represents the gradient of each unit's subsurface depth as the depth decreases towards the shelf. In all maps a distinct "W" shape can be seen in Reagan County subsurface contours, which indicates a long-lived, persistent local structure. The development of the Midland basin in these counties shows progradational growth of the Eastern shelf, which is consistent with previously published models.

THE DAGGER FLAT MAGNETIC ANOMALY: MAFIC SILL AND CORRELATION WITH SURFACE GEOLOGY, BIG BEND NATIONAL PARK, TEXAS

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A significant positive magnetic anomaly occurs in the Dagger Flat area of Big Bend National Park. The anomaly is thought to indicate the presence of a major laccolith beneath that area, comparable in size to those nearby at Rosillos Mt and McKinney Hills. Although two thin gabbroic sills are exposed along the eastern side of Dagger Flat, the surface geology shows no indication of doming over the supposed laccolith. Variations in the magnetic anomaly correspond closely with positions of normal faults, and clearly show where those faults extend beneath Quaternary alluvial cover. Given the elevation and attitude of strata over the intrusion, a major laccolith cannot be accommodated beneath Dagger Flat, and instead the intensity of the magnetic anomaly there may reflect the gabbroic composition of the sills.

The Effect of Hydraulic Fracturing: Is it Worth the Cost?

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Oil and gas companies use a technique called hydraulic fracturing to extract natural gas from deep wells. The technology is leading to energy independence for America, but not without controversy. The problems addressed in this project are limited to the following issues:

(1) Contamination of aquifers from the wastewater by-product of fracking
(2) The amount of fresh water required to fracture shale

To address these two problems, the Water Warriors developed several tests to determine how flowback affects living organisms. The team developed a way to effectively clean the wastewater for reuse and for cleaner injection into storage wells underground.

To test the danger of flowback water, it was used to germinate seeds, to water plants, and as a habitat for Planaria. In each case, flowback water had negative effects on life. The water itself was tested and found to contain higher than expected levels of many dangerous chemicals.

The team designed four types of distillation units to be adapted for use in the oilfield. Fracking water was distilled in the

lab and the most effective unit reclaimed 90% of the water for reuse.

Analyzing the Effects of Evaporation on the Elevation Change of Lake Alan Henry

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In this study, the daily changes of elevation in Lake Alan Henry are studied in regards to factors influencing change because elevation changes in part reflect effects of evaporation on the lake. The United States Geologic Survey (USGS) collected a major component of the data that was used in this report. The streamflow into the lake was collected from the long-term USGS streamflow-gaging station on the Brazos River in Justiceburg, Texas about 10 miles upstream from the Lake Alan Henry dam. The lake elevation data was acquired from another USGS gage monitoring the elevation of the lake on a day by day basis. The atmospheric conditions were collected through a Texas Tech operated Mesonet station that is location near the reservoir. The period analyzed was September 1, 2005 through April 14, 2014. Daily changes in elevation were selected from long-term record and adjusted with regard to major natural inputs and outputs during periods lacking short duration hydrologic phenomena. For example, unnatural conditions are when the water in the lake is at such an elevation that water goes over the spillway and when Lubbock extracts water from the reservoir for municipal use. The inputs of rainwater and flow were accounted for, and so were the atmospheric parameters of temperature, solar radiation, relative humidity, and time of year.

The study did not stop at finding the daily change in elevation and attribute all changes to evaporation or the lack there of.

Native Bees – A Pollination Sensation

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The population of European honeybees has been in sharp and steady decline over the past decade. The usefulness of pollinators to the global food production cannot be overstated. Can wild native bee populations take over the niche of pollinating native plants and be helpful for commercial crops as well? There is little research available to help answer that question, so the Pollination Sensation team began a quest with other pioneers interested in native bees. The following tasks led to a solution ---

*Assessed a number of native pollinators in an urban area and rural area on the South Plains
*Looked at the different colors that attracted native pollinators and used an effective blue-vane trap
*Beta-tested the FoldScope – a paper full powered microscope developed by Stanford University
*Conducted research online to learn more about native pollinators' habits and identification
*Designed pseudo-biological pollinators or artificial pollinators and have blueprints for 3D technology

Results:
*Native pollinators were found in abundance and diversity on the South Plains
*Gardens were planned with pollinator-friendly species in mind
*Bee nests were developed and distributed in communities to encourage non-stinging native bees

Careful stewardship of our plants and pollinators will ensure a secure global food source thanks to native bees.

Development of the Horseshoe Atoll in the Northern Midland Basin, Howard and Mitchell Counties, Texas

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The Horseshoe Atoll is a late Paleozoic carbonate buildup that forms a paleotopographic high within the northern part of the Midland Basin. Sub-surface structure and stratigraphy of the Pennsylvanian evolution of the Horseshoe atoll within Howard and Mitchell counties are the focus of this paper. Structure maps (reported in feet below sea level) have been produced using fusulinid biostratigraphic tops in wells drilled from the 1940's to the 1970's.

The Lower Strawn stage (middle Desmoinesian) structure map displays the broader topographic beginnings of the reef structure that would later become the atoll. The Canyon stage (Missourian) structure map demonstrates the topographic highs of the reefs forming the southern edge of the Horseshoe Atoll. Taken together these two maps visualize the evolution of the southern edge of the Horseshoe Atoll such that reef topography generated from this study agrees well with previously published atoll extent. The relative absence of Wolfcamp fusulinids may reflect the end of carbonate sedimentation in the Horseshoe Atoll. This could possibly be due to the eastern shelf encroaching on the atoll and thus depositing more basin center clastics through sediment gravity flows.

A Small Theropod Dinosaur from the Aguja Formation (Upper Cretaceous), Big Bend National Park, Texas

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The remains of theropod dinosaurs are remarkably scarce and usually very fragmentary in Upper Cretaceous strata of Big Bend National Park. Most taxa have been identified or named based on dental elements alone, or on isolated finds consisting of no

more than one or two bones. Parts of an associated postcranial skeleton of a small theropod dinosaur recently collected from the uppermost Aguja Formation comprise the most complete example thus far recovered in Big Bend. The specimen exhibits some unique features, but is compatible with identification as either Troodontidae or Dromaeosauridae.

MAXIMIZING HORIZONTAL PLACEMENT USING MULTIPLE OOIP ESTIMATES IN THIRD BONE SPRING SANDSTONE

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The third Bone Spring sandstone is part of a widely dispersed network of submarine fan deposits located in the Delaware basin[1]. This study looked to optimize horizontal well placement in the formation at depths from 9590'-9920'. ECS log data suggests most of the unit is a shaley sandstone with 3'-9' thick carbonate stringers present in the interval. Resistivity invasion profiles suggest movable hydrocarbons are present within the interval and above the suggested formation top. Four separate estimates of OOIP at 160 acre spacing were calculated, including OOIP by variable matrix analysis using ECS log data, CMR CBP6 cut off, bitumen correction, and S1 volatilization methods. A movable hydrocarbon index cutoff of >0.7 was applied to these estimates in order to optimize horizontal well placement. Our recommendation is to place a horizontal well at 9700' assuming a 300ft fracture interval. Fracturing is expected to exceed the formation interval top by 40' to a depth 9550'. This recommendation will increase reserves 34-56% based on calculated OOIP estimates with a MHI cut off of >0.7. OOIP estimates for the fracture interval range from 4.1-1.9 MMstb.

[1]Montgomery, S. L., 1997. Permian Bone Spring Formation: Sandstone Play in the Delaware Basin, Part II—Basin. *AAPG Bulletin,* 81(9), pp. 1423-1434.

DEVELOPMENT OF THE EASTERN MIDLAND BASIN SHELF WITHIN TOM GREEN COUNTY, TEXAS

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The purpose of this paper is to assess the evolution of the eastern Midland basin within Tom Green County. Depths of biostratigraphic zones were mined from wells drilled in the 1940's to the 1970's and utilized to build structure maps of chronostratigraphic horizons. Overall, the eastern shelf as illuminated through the biostratigraphic data mined in this study agrees broadly with most other studies, yet the data presented here appears to detail that evolution in more detail. For example, most authors depict expansive westward progression of the shelf in the early Permian, a relationship observed in this study. Moreover, detail structure of the Pennsylvanian and early Permian shelf suggest localized lobes of sedimentation that show the carbonate shelf's movement.

STRIKE-SLIP DISPLACEMENT ON BASIN & RANGE FAULTS BOUNDING THE NEOGENE ESTUFA BOLSON, BIG BEND NATIONAL PARK, TEXAS

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An east-trending 3 km long basalt dike near the San Vicente cemetery in Big Bend National Park is offset in numerous places by small-scale left-lateral strike-slip faults, and provides a piercing point to evaluate the magnitude of strike-slip displacement. Collectively, the offsets on the faults indicate a minimum of about 800 m of left-lateral slip. This zone of deformation appears to coincide with the eastern boundary of the Estufa Bolson, a graben that formed during Basin and Range tectonism in Neogene time. Differential movement on faults bounding the bolson margin may account for the left-lateral strike-slip displacement, contrary to the regional Basin and Range right trans-tensional stress field.

LATE CRETACEOUS LATERITIC PALEOSOL IN THE TORNILLO GROUP, BIG BEND NATIONAL PARK, TEXAS

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The Upper Cretaceous to Paleogene Tornillo Group in the Big Bend region consists of fluvial sediments with multiple buried soil profiles (paleosols). Most of these paleosols are immature floodplain soils that had not developed very long prior to being buried by overbank sediments. One paleosol is unusual, only found at a few sites, and appears to exhibit a plinthite horizon within a very mature well-developed lateritic type of soil. This paleosol is found in the lower part of the Black Peaks Formation just below the Cretaceous-Paleogene boundary interval. The presence of the plinthite bed indicates that this interval experienced prolonged weathering and leaching, kaolinite clay accumulation, and iron-oxide concretion development within a fluctuating water table. The absence of a preserved A-horizon above the plinthite bed, and the presence of grain-to-grain contacts around most of the iron-oxide concretions, suggests that this soil experienced erosion prior to burial. This situation is similar to modern plinthite-bearing Ultisols and Oxisols that tend to form on older and higher parts of tropical landscapes subject to erosion and drying after deforestation.

DEVELOPMENT OF THE WOLFCAMP FORMATION AND HORSESHOE ATOLL IN THE MIDLAND BASIN, BORDEN AND SCURRY COUNTY, TEXAS

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The Permian Basin is a hydrocarbon province that is located in west Texas and southeastern New Mexico. The Midland basin comprises the eastern portion of the greater Permian basin

region. The Midland basin accumulated predominantly carbonates with minor siliciclastics during the Pennsylvanian epoch and Permian period. Carbonate growth was located along the shelf which continued to steep and prograde from the middle Pennsylvanian to Wolfcampian time. Data from the 1940's to the 1970's utilizes fusulinid biostratigraphic zone tops to construct topographic maps of the eastern shelf of the Midland Basin and Horseshoe Atoll in Borden and Scurry County.

The map of the Lower Strawn Formation displays the paleotopography of the Horseshoe Atoll as it began to form during the Desmoinesian. The Canyon Series map represents the maximum topography of the atoll during the Missourian. The two maps display that carbonate growth of the atoll within the study area. Previous research of the Horseshoe Atoll is geographically validated, allowing for future improvement on the accuracy of the atoll's growth. The Wolfcamp Formation map displays the sedimentation of the Horseshoe Atoll and growth along the eastern shelf of the Midland Basin during Wolfcampian time. These maps display the evolution of the basin and validate previous research, allowing further interpretation of the depositional environment and the development of current hydrocarbon province.

WELL LOG ANALYSIS AND HORIZONTAL DRILL PLACEMENT OF THE 3RD BONE SPRING SANDSTONE, DELAWARE BASIN

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The 3rd Bone Spring Sandstone has recently shown to be a promising production zone, becoming one of the most horizontally drilled zones in the Delaware Basin. Petrophysical analysis was performed on a set of well log data to determine the optimal producible zones and horizontal drill placement. Quick look analysis was performed to determine potential zones. Cutoffs for quick look analysis are as follows; Swe < 45%, ϕ_e > 4%, ϕ_{oil} > 2%, K > 300 nD, and 2% < TOC% < 10%. A potential zone was determined to be between 9620' and 9850'. MHI for this zone is below the max cutoff of 0.70, showing that there are good moveable hydrocarbons. Total OOIP for this zone is 2.8 MMstb, and assuming a recovery of 5%, 141 Mbstb. Horizontal well placement was determined to be optimal at 9730' based on the presence of moveable hydrocarbons, an increase in OOIP, TOC%, ϕ_{oil} and ϕ_e, and a decrease in Swe. Brittleness and minimum closure stress both indicate that a horizontal fracture can be sustained here.

PETROGRAPHY OF MUDROCKS IN THE BARNETT SHALE, MARBLE FALLS FORMATION, AND SMITHWICK SHALE (MISSISSIPPIAN-PENNSYLVANIAN) FORTH WORTH BASIN, TEXAS

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Black shales in the Barnett, Marble Falls and Smithwick include abundant organic matter, varied amounts of silt, siliceous and carbonate bioclasts, phosphate, glauconite, and diagenetic minerals. Petrographic study of these "shales" indicates that some are actually siltstones, marlstones, or phosphorites using a traditional classification. If the relative abundances of constituents determined petrographically can be employed in the Schlumberger sCore method, most of the true shales are silica-rich argillaceous mudstone or mixed mudstone in that classification. In contrast, reservoir-quality shales in the Barnett were found to be mostly clay-rich siliceous mudstone in a Schlumberger case study. This may indicate that petrographic analysis overestimates the amount of clay, or that most Barnett reservoirs have higher silt content than the shales sampled in the present study.

THE GREENLAND ICE SHEET AND CLIMATE CHANGE: A SYSTEMATIC REVIEW

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There is a vast amount of research pertaining to the Greenland Ice Sheet and the current climate change. It is a rapidly growing topic of importance because the complete melting of the 2.85 million km^3 ice sheet would result in a 7 meter rise in the global sea level, which would effectively put a large number of highly populated cities completely underwater. There are many different researchers from a myriad of specialties pertaining to glaciology and climatology. Constraining and summarizing the results of the research is pertinent to the growing concern for the future of our Earth. Many politicians and policy makers look towards scientist's research so they can make informed decisions. However with such a range of research, they aren't getting the whole picture. After performing a search through a range of databases for studies pertaining to the Greenland Ice Sheet and climate change, I narrowed down the studies to a group of roughly 15 papers and did an in depth mixed studies and mixed methods review. Essentially, the combined research states that the GIS has an increased number of "glacial quakes" which is due to increased melting and more calving events. Additionally, warming trends tend to happen quicker cooling periods however warming trends show an increase in layer thickness. It was also found that the North Atlantic climate has been widely unstable and that changes can occur much more rapidly than previously thought which could suggest a shift in atmospheric and ocean circulation. Furthermore, an increase of 1°C increases glacial runoff by 40% and also increases accumulation, which results in a sea level raise of .22mm per year. Additionally, the total mass loss will increase exponentially after 2060. However, some of the models used were found to be too simple to answer certain questions.

TRACKING WATER INFILTRATION IN A PLAYA LAKE USING DIFFERENTIAL GRAVITY

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Playa lakes are ave served a significant role in the history of life on the Southern High Plains. They have served everything as Buffalo Wallos to a substitute water source for farmers who couldn't afford to drill a well. Perhaps their most significant role on the Southern High Plains is as a source of recharge for the Ogallala Aquifer, which is geologically cut off from other sources of recharge.

The objective of this paper is to determine if it is possible to monitor saturation beneath a playa lake using a differential gravity meter.

The gravity readings will be collected over multiple trips, spanning several months, to a playa lake WSW of Wollforth, TX using a differential gravity meter provided by Dr. Gurolla and Texas Tech University Geosciences Department. After collection the readings will be processed using the Bouguer, Free-air, and Terrain corrections, then plotted. The first set of readings were taken after a month of heavy storms. These readings will be compared to readings after a dry period.

Then the change in gravity from the first and last gravity readings were used to calculate the volume of water penetrating needed to create such a gravity change. In order to do this Guasses law was used. Then the profile of the playa was taken to represent what any radial profile would look like and then calculated the volume which came out to 13,604m^3. This number would then be compared to an estimated volume of water that would penetrate soil with 30% porosity after an estimated 90% of the water evaporated (calculated in an earlier study done by William Shwiesow) off of the surface of the playa. The water column height required to contain as much water as needed to give the results found in the study is 380m, compared to the less than 100m water table.

Based on these results, it is concluded that the range in values must be noise since the amount of water that is required to produce the anomaly is more than possible. However, this doesn't mean that it is impossible to track saturation with a differential gravity meter. A suggestion to increase reliability of the data is to increase the number of readings at each station as well as the use of a newer meter. Doing these two things could provide better results in a later study.

NON- DESTRUCTIVE COMPUTER TOMOGRAPHY AS A TOOL OF VISUALIZATION AND QUANTITATIVE ANALYSIS OF GABBROIC CORE FROM ATLANTIS BANK, SOUTHWEST INDIAN RIDGE

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Computer tomography is non-destructive technique that can be used to study different types of rock with different sizes and different composition to better constrain the 3-D structure of different density materials. The image resolution and details is based up on the quality and the strength of the x-ray beam and the type of the software used to process the raw images. The quality of the 3D images is depending on the slice thickness of the images, as the slice thickness gets smaller with high intensity beam the greater the details on the 3D animation. We have successfully applied the computer tomography technique to evaluate the composition and the 3D fabric structure and to identify different minerals at gabbroic sample from the Atlantis Bank, Southwest Indian Ridge. Linear attenuation coefficient theory is the basic premise behind the computer tomography technique. The higher the value of the linear attenuation coefficient the higher the absorption of x- ray and the more the mineral will appear brighter in the grayscale images corresponding to a higher density phase. Three different minerals were identified according to their densities and brightness. The higher the density of a mineral the brighter the mineral will appear in the grayscale images. Magnetite has the highest density with the brightest appearance, pyroxene has intermediate density with intermediate brightness and plagioclase has the lowest density with dark appearance. 3D animation, volume rendering, density measurement and multiplanar reconstruction were done using OsiriX medical software. Calculating the volume shows that pyroxene has the highest abundance, the second highest abundance is plagioclase and the lowest abundance is magnetite. 3D animation gave the ability to cut through the image and evaluate the internal structure of the core without cutting the actual sample.

WELL LOG ANALYSIS OF THE 3RD BONE SPRING FORMATION

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The Permian Basin is very attractive to oil companies and researchers due to the fact that it has the biggest potential oil production in the nation by 29% (e.g., Dutton, et al., 2003; Root, Attanasi, Mast, & Gautier, 1995; Galloway, et al., 1983). The area of the basin is roughly 86,000 square miles in Texas and New Mexico. The sub-basin of interest is situated to the West of the Central Platform in the Delaware Basin and covers approximately 10,000 square miles. The assigned formation for evaluation was the 3rd Bone Spring sitting immediately above the Wolfcamp and located in the Leonardian period. The 3rd Bone Spring formation is predominantly shaly-sand with intermittently inter-bedded carbonate layers.

A full well-log suite including geochemical data was presented in the assignment for analysis. A series of systematic calculations were performed in both software programs Microsoft Excel (2013) and Techlog by Schlumberger (2013). Assigned calculations included; (1) thermal maturity using vitrinite reflectance, (2) total porosity, (3) effective porosity, (4) total organic carbon, (5) variable matrix analysis, (6) clay bound water, (7) OOIP using variable matrix analysis, (8) bitumen corrected OOIP, (9) T2 cutoff OOIP, (10) OOIP from rock evaluation data (S1), and finally (11) geo-mechanics. In addition, to generate rigorously defined conservative OOIP

estimates and precise optimization of horizontal well placement we developed new and creative methods.

The most conservative OOIP estimate using multiple stacked pay flags (MHI and Permeability combined) came from the Bitumen Corrected OOIP at 9700ft and an EUR of 0.9 MMstb. More precisely, the least conservative OOIP estimate using multiple stacked pay flags came from Variable Matrix Analysis using ECS data at 9698.5ft and an EUR of 4.1 MMstb. Finally, all optimized zones peaked within 5ft of each other regardless of the method of OOIP calculation. Given this additional level of assurance we determined the optimal placement was at 9700ft. This depth has a carbonate dominated layer with a marked decrease in gamma ray count allowing for accurate geolocation and geo-steering of the well bore.

STRUCTURAL AND KINEMATIC ANALYSIS ON SATURN'S ICY SATALLITE ENCELADUS

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A structural analysis was completed on the equatorial regions of Enceladus, a tectonically active, icy satellite of Saturn. Using three NASA Cassini images, more than 3,000 fractures, ridges, and troughs were mapped. Eight different groups of structures were identified based on cross cutting relationships, morphology, and orientation. These groups include 1) four linear, parallel to subparallel fracture sets of differing age and morphology, 2) a set of antiformal and synformal structures that pre-date all fracture sets, 3) curved scarps 3 km to 66 km in length that predate the fracture sets and fold structures, and 4) two chronologically different sets of wave-like corrugated ridges which represent the oldest structures in the study area. The four fracture sets (Group 1) have distinct popultions that trend 15.5°, 354.6°, 328.6°, and 20.0°. Group 2 folds trend 326.7°, and Group 3 structures trend 269.6°. The corrugated ridges (Group 4) trend 22.8° and 276.1°.

The distribution and relationship between spacing and orientation and spacing and length was graphed. Spacing between individual structures within a distinctivly orientated group of structures is normally distributed with an average spacing of 0.915 km for three fracture sets, 1.45 km for one fracture set, 4.43 km for the folds, 1.83 km for the scarps, and 9.78 km for Group 4. Large distances between irregularly spaced features correlate to shorter structure lengths. One fracture set has an average length and spacing of 14.58 km and 3.43 km respectively. Other fracture sets have an average length and spacing of 4.67 km and 2.97 km, 9.38 km and 4.4 km, and 5.13 km and 3.08 km. These observations indicate a possible variation in lithosphere thickness in these areas.

Based on the morphology and orientation, fracture sets and scarps are hypothesized to be the result of extensional strain, whereas the sets of corrugated ridges and folds are the result of contractional strain. The maximum principal stress is orientated N-S, and the minimum principal stress is orientated equatorially. Variations in the orientations of the fracture sets suggests a shifting strain field which likely indicates the icy lithosphere is subjected to nonsynchronous rotation. This, in turn, would imply the existence of a global ocean beneath the lithosphere. In order for nonsynchronous rotation of the icy lithosphere to occur, a global ocean must be present to decouple the lithosphere and allow it to rotate[1].

[1] Patthoff, D. A et al. (2011) *Geophys. Res. Lett.* 38, 1-6.

SEQUENCE STRATIGRAPHY OF THE BEEMAN FORMATION USING CONODONT IDENTIFICATION OF INDIAN WELLS, SACRAMENTO MOUNTAINS, NEW MEXICO

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The Beeman Formation in the Sacramento Mountains in south-central New Mexico is Missourian (Late Pennsylvanian) in age based on new conodont collections from a section in Indian Wells Canyon. The lower beds of the Beeman Formation comprise an early Missourian carbonate and black shale unit that is correlated with the Midcontinent Hushpuckney Shale (Swope Cyclothem). It represents a regional early Missourian flooding event. The overlying thick section of terrigenous clastics contains inter-bedded shales and sandstones and includes at least one level with a diverse plant flora and lake deposits. This clastic interval possibly represents a period of activation and erosion of orogenic source areas. The transition from these clastics to the upper carbonate and shale unit of the Beeman represents a second flooding event. Conodont data from near the base of the upper carbonate unit shows that the start of shallow water carbonate deposition correlates with the middle Missourian Hogshooter cyclothem. Multiple levels with conodonts show that carbonate deposition persisted at least as high as the middle Missourian Plattsburg cyclothem, and perhaps as high as the late Missourian Stanton cyclothem. These age data contradict the cycle-by cycle correlation of Beeman cycles to the Midcontinent cyclothems proposed by Raatz [1,2].

[1] Raatz, W.D. (1996), Unpub. PhD dissertation, Univ. Wisconsin, 404 p.

[2] Raatz, W.D., and Simo, J.A., 1998, The Beeman Formation (Upper Pennsylvanian) of the Sacramento Mountains, New Mexico: Guide to the Dry Canyon area with discussion on shelf and basin response to eustasy, tectonics, and climate: New Mexico Geological Society 49th Field Conference, Guidebook, p. 161-176.

THE SOURCE OF CRETACEOUS ROCK CLASTS FOUND IN GRAVELS OF THE OGALLALA FORMATION IN WEST TEXAS

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Conglomerates in the Miocene-Pliocene Ogalalla Formation on the Southern High Plains of West Texas contain pebbles and cobbles derived from a wide variety of source areas. One of the distinctive clast types found in Ogallala gravel consists of sandy gryphaeid oyster coquina and fossiliferous quartzose sandstone with similar gryphaeid bivalves. The fossil content suggests that the clasts were derived from nearby Cretaceous clastic sedimentary rocks such as the Duck Creek Formation in Texas,

or the Glencairn Formation, Tucumcari Shale, or Dakota Group in eastern New Mexico. The mineralogy and texture of the sandstone suggests that the clasts were derived from the Mesa Rica Sandstone, but similar coquinas have not been described from that formation. Gryphaeid coquina beds are widespread in the Glencairn Formation in far northeastern New Mexico, but those exposures are 250 to 400 km away from the Ogallala outcrops in Texas. It seems unlikely that the Ogallala clasts were transported that far from their source. The Glencairn "*Gryphaea* bed" facies may have originally been more widespread, closer to the Ogallala outcrops, but were largely eroded away prior to and during deposition of the Ogallala Formation.

THE ASSOCIATION OF DRYLINE CONVECTION WITH THE EL NINO SOUTHERN OSCILLATION

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The purpose of this study is to find a relationship, if any, between thunderstorm development along the dryline and the El Nino Southern Oscillation (ENSO). Using the past fourteen years (2001-2014), the strongest El Nino and La Nina year was selected using values of the Southern Oscillation Index. 2002 was found to have the highest correlation with the El Nino phase and 2011 was found to have the highest correlation with the La Nina phase. The April-June period of each year was examined to find the number of drylines that each contained. The number of drylines was determined using DIFAX maps (within a square area extending 250 miles north, south, east and west from Lubbock) of times between 21:00 and 00:00 UTC, for every day of April through June of the El Nino/La Nina years.

Of the 184 days that were observed in 2002 and 2011, 78 of them had a dryline lying within the West Texas Mesonet area. Of the 78 drylines observed 34 of them fell in the El Nino year (2002) and the other 44 fell in the La Nina year (2011). After finding the dates containing drylines they were then further examined to determine convection and tornadic development. Convection was found on 22 of the El Nino drylines and 13 of the La Nina drylines. Of the drylines with convection there were 8 containing tornadic activity for El Nino, and 2 containing tornadic activity for La Nina. The role of water vapor content and vertical wind shear are both considered as explanations for these differences.

PREDICTING PARTIAL-MELT SOURCES AND COMPOSITIONS IN THE RUBY MOUNTAINS – EAST HUMBOLDT RANGE THROUGH BULK-ROCK COMPOSITIONAL MODELLING

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Voluminous granites are pervasive in the Ruby Mountains (RM) – East Humboldt Range (EHR), Nevada. The granites are the product of partial-melting of metasedimentary crustal sources and have crystallization ages between 80 and 30 Ma (Romanoski, 2012). In the EHR voluminous biotite monzogranites were attributed to partial melting of Neoproterozoic McCoy Creek Group rocks (Sicard, 2012). A similar source was proposed for the emplacement of Cretaceous sheets, dikes and pods of leucocratic granite, particularly in Lamoille Canyon (RM).

Assemblages for a range of effective bulk compositions were calculated to determine the P-T limits of partial melting. Results were compatible with crustal anatexis perhaps during mylonitization of the mid-crust during Tertiary extension after Nevadaplano collapse, and prograde dehydration during crustal over-thickening in the Sevier hinterland. Melt compositions were calculated and compared to granite compositions.

Modelling of McCoy Creek compositions from the south EHR suggest partial melting occurred at 6.5-7 kb and ~700 ºC producing highly leucocratic compositions. These reactions are exposed as stromatic migmatites, and modeled compositions are comparable to sampled late Cretaceous peraluminous melts. The occurrence of sheet-like leucogranite melts in the south EHR suggest Sevier crustal thickening as a mechanism to produce the small volume, but wide-spread low-temperature granites of late-Cretaceous age.

TWQ-estimated metamorphic conditions of 7.2 kb and 735ºC for samples at Clover Hill near the north EHR are above the modelled partial melting curve (Sicard, 2012). Modeling suggests P-T conditions in the upper amphibolite facies zone, again compatible with Sevier Orogenesis and crustal thickening.

Partial melting of metapelites richer in Fe, Mg and K may have produced a peraluminous melt with biotite, comparable to the biotite monzogranites. In contrast, McCoy Creek compositions with lower Fe, Mg and K abundance may have resulted in final produced the sheets and dikes of leucocratic granite. Compositional variability in the McCoy Creek Group protolith may explain how a single unit could produce the observed diversity of magmatic rocks.

SEISMIC MAPPING OF SEDIMENTARY STRATA AND FAULTS IN THE NORTHERN MATAGORDA ISLAND AREA OF THE GULF OF MEXICO

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The Gulf of Mexico formed in the late Triassic to the Early Jurassic periods in the space between the African, North American, and South American plates. Since that time nearly 200 million years ago, the Gulf has been filling with sediment, forming contemporaneous faults and creating hydrocarbon traps along its margins. Understanding the development of these faults is vital to hydrocarbon exploration. For this project, seismic reflection data from the 1970s were reanalyzed with the purpose of mapping seismic horizons and faults in an area just offshore of Victoria, Texas, in the Matagorda Island federal lease area. A grid of 12 seismic sections, velocity surveys from 5 wells, and fossil records from 4 wells were examined and yielded a 3-dimensional map of major stratigraphic horizons and faults in the study area. The map reveals what appears to be an oddly positioned, northwest-southeast running graben that is nearly

perpendicular to most of the other faults in this area, which run parallel to the shoreline. We postulate these faults to either be a segment of another larger, shoreline-parallel growth fault system that has been locally oriented in its current state, or that the graben could be constructed by a rising shale diapir.

A Study of the Temporal and Spatial Relationships of Gypsum Veins, Faults, and Fractures in Caprock Canyons State Park, Briscoe County Texas

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The outcrops in the Quartermaster Formation at Caprock Canyons State Park in the Texas Panhandle display gypsum veining in networks that crosscut red mudstone layers in the area. Previous research in the area has shown that this gypsum veining is a secondary structure that came sometime after the deposition of the original beds. The focus of this project is to determine the temporal and spatial relationships of these gypsum veins and the faults and fractures within selected well-exposed cliff faces along the South Prong of the Little Red River in the area.

Structural data including vein and fracture orientation, displacement, thickness and density were collected along a transect on the South Prong of the Little Red River through the Quartermaster Formation. Observations made concerning cross cutting relationships between the gypsum veins, fractures, and faults were established on detailed panoramic maps. Based on this mapping I propose a sequence of structural events as follows: 1) Fracturing (including steep Mode I and inclined shear fractures), 2) dip-slip faulting with dominantly normal apparent offset, 3) minor reverse/thrust faulting, 4) gypsum vein formation, and 5) post-vein steep fracturing. Crosscutting relationships indicate that gypsum veins cut across steeply dipping fractures, indicating that the gypsum veins post-date fracturing events in the mudstone beds. The average vein thickness in the study area ranges from 0.5 mm to 7 mm with a large portion of them falling between 1 mm to 3.5 mm. Faults with the area display a general east-west trend with north and south dips between 45º and 70º, with normal apparent offsets; the gypsum filled veins also show this same east to west trend with north and south dips ranging from 25º to 65º. Field observations of the fault plains show gypsum growth in the faults, indicating that faulting happened before the gypsum crystallized. Virtually all of the gypsum veins contain vertically-oriented crystal fibers, regardless of vein orientation. If the vertical fibers define the extension direction, then this ubiquitous observation indicates that vein formation occurred during subsidence of the sedimentary section below the level of exposure. These findings are consistent with the conclusion that the gypsum veins crystallized after the formation of the fractures and faults.

Structure of the Ordovician Ellenburger Formation in Fisher and Nolan Counties, Texas

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The section of the Permian Basin located in western Texas contains a suite of Paleozoic carbonate and shale formations deposited in a marine environment. At the lower stratigraphic end of the Permian Basin lies the Ordovician Ellenburger Formation. The Ellenburger Formation is a karsted dolomite mudstone that was deposited when Texas was still a shallow water shelf. Through a period of elapsed eustatic sea level fall, the Ellenburger Formation did not receive sufficient sedimentation to be buried. The resulting dissolution of the dolomite caused karsting. Due to the depth of the Ellenburger Formation and its karsted surface, it is a difficult subsurface unit to map.

Using biostratigraphic zone tops (reported in feet below sea level), this research assesses the structure of the top of the Ellenberger Formation within Fisher and Nolan Counties. Structural representations of the Ellenburger created from biostratigraphic zone tops coincides with depositional and paleogeographic models both in location and in orientation. Although a karsting related paleotopography is present with the Ellenburger Formation, the structure and location of the Ellenburger's subsurface map suggests that diagenesis of this unit was not detrimental enough to disenfranchise it from previous findings.

The Mississippian Chappel Limestone, Subsurface Shackelford County, Texas

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A number of oil and gas fields in the Fort Worth Basin, Texas, produce from a Mississippian carbonate unit referred to as the Chappel Limestone. These strata comprise a series of mud mounds and associated mound flank facies. A core of "Chappel Limestone" from Shackelford County, 166 ft., was provided by S. Ruppel of the Bureau of Economic Geology (Austin) for petrographic and biostratigraphic comparison with the type Chappel Limestone of other Llano Region. The core shows 10 distinct units, (A-J), from bottom to top. The lower most units, (A and B), contain packstone with alternating, interbedded shale. Units C - E contain alternating packstone with red mud and interbedded shale. Units F-I contain primarily clean grainstone with a vuggy interval. The upper most unit J contains grainstone with interbedded Barnett Shale. All units contain bryozoan and crinoid grains.

This facies succession represents a transition from an argillaceous pre-mound facies (Units A and B) to mound flank facies (Units C-E) and possibly shallow water grainstones capping the adjacent mud mound and associated facies. Conodont faunas show that Units A and B are late Kinderhookian in age (*Siphonodella* zones) and are slightly older than the type Chappel. Units C, D, and E are early Osagean in age (*Bactrognathus* and *Gnathodus* zones). These units are same age as the type Chappel and also the age of comparable, well studied mud mound successions in the Sacramento

Mountains, New Mexico. Units F through I are late in age (*Gnathodus* zones) and are slightly younger than the type Chappel. Unit J, just below the basal beds of the Barnett Shale are latest Osagean to early Meramecian in age.[1] Thus, the Chappel Limestone in subsurface Shackelford County comprises a greater range of time than the thin Chappel sections in the Llano region.

[1] Boardman et al. (2013). High-Resolution Conodont Zonation for Kinderhookian (Middle Tournaisian) and Osagean (Upper Tournaisian-Lower Visean) Strata of the Eastern Edge of the Ozark Plateau, North America, volume 64, p. 98-151.

DEVELOPMENT OF THE PERMIAN SHELF IN THE NORTHERN MIDLAND BASIN GARZA AND CROSBY COUNTIES TEXAS

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The Permian Basin is a culmination of carbonate growth on the shelves, and deposition and subsidence in the basins to produce a well-defined shelf bordering a deep basin during Pennsylvanian to Permian. As the Marathon Belt continued to load the North American plate during the formation of Pangea, basin subsidence ensued forming the structure of the Permian Basin which consists of two basins and an uplifted platform separating the two basins. Sedimentation in the eastern Midland Basin is largely carbonate on the shelf and deep water pelagic and hemi-pelagic shales and turbidite detritus in basinal locations.

Maps of the Permian Basin shelf have been produced by others showing a generalized shape of the shelf surrounding the basin. Crosby and Garza counties lie on the north-eastern shelf of the Midland Basin and are the focus of this paper. Fusulinid biostratigraphic and stratigraphic thickness data from the 1940's to the 1970's was used to produce maps of Pennsylvanian and Permian time to compare to more recent paleogeographic maps. The maps produced in this paper reinforce the position of the northern Midland Basin shelf, while showing greater detail of the study area through structure and isopach maps. Thickening occurred on the shelf rather than in the basin indicating sufficient accommodation space to accumulate both siliciclastic and carbonate sedimentation upon the shelf. Local structural lows correspond to stratigraphic thin intervals in a shelfal position are tentatively inferred as valleys cutting through the shelf during the Permian as bypass zone delivering turbidites to the deeper basin.

PENNSYLVANIAN DEVELOPMENT OF THE HORSESHOE ATOLL IN THE MIDLAND BASIN, MARTIN AND DAWSON COUNTIES, WEST TEXAS

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The Midland Basin formed during the Middle Pennsylvanian as a result of the uplift of the Central Basin Platform segmenting the older Tobosa Basin. The uplift was caused by the collision of Laurentia and Gondwana during the amalgamation of Pangea. Located in the central Midland Basin is an arcuate shaped, carbonate buildup, termed the Horseshoe Atoll, that initiated in the Middle Pennsylvanian (Strawn) and ended by the early Permian (Wolfcampian). During the middle to late Pennsylvanian, amalgamation of individual reef complexes coalesced to form the larger atoll system. However, by early Permian carbonate production appears to have ceased. Fusulinid biostratigraphic zone tops collected from wells drilled in the 1940's through 1970's within Dawson and Martin counties allow for a chronostratigraphic reconstruction of the geometric evolution of the atoll. The Wolfcampian (Early Permian), Lower Strawn (Middle Pennsylvanian), and Canyon (Upper Pennsylvanian) structure horizons were used to demonstrate the evolution. In western Dawson County, structural highs with intervening lows are present on the Lower Strawn chronostratigraphic surface which likely represents initiation of isolated reefs. However, by Canyon and Early Permian time, those isolated highs are more coalesced into broader regions of structural elevation likely indicating the amalgamation of isolated reefs into the larger atoll system.

STATISTICAL VARIATIONS IN VEIN DENSITY, AND LATERAL AND STRATIGRAPHIC VARIATIONS IN DENSITY DISTRIBUTION WHILE COMPARING DATA COLLECTION METHODOLOGIES, CAPROCK CANYONS STATE PARK, TEXAS

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Caprock Canyon Texas State Park is located in the Rolling Plains of Texas, just a few miles Northeast of Plainview Texas. The rugged relief provided numerous cliff exposures along the edge of Caprock, allowing 3D veiws of veining and fracturing produced by underlying salt dissolution. Eight outrops were studied using a 1mx1m wooden frame, Adobe© Illustrator© and Panoramic photos of each location using the Scanline and Window methodology of measuring vein density. Each outcrop was broken down into a minimum of two sections and then processed at both the outcrop and study area scale. This data was used to gain an understanding of statistical variations in vein denisty, and lateral and stratigraphic variations in vein distribution. At the outcrop scale the density of veins range from 3-8 veins per square meter. And at the regional scale the density of veins range from 3-8 veins per square meter. The Scanline and Window method of measuring vein density is compared and contrasted to better understand data method accuracy.

WELL ANALYSIS PERMIAN 3rd BONE SPRING SANDSTONE

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The "Permian Basin" Shale is a lithological heterogeneous basin; it is a laminated sandy organic-rich shale reservoir. The formation depth is from 9,400' to 10,000' which is translated to 600' thickness. An interval of 330' was the target in this study. Openhole logs were collected from the pilot hole, and then the

decision of horizontal well was made based on the effective porosity, water saturation, permeability, TOC, MBI, and OOIP. The proposed horizontal well targets the primary objective interval (from 9,590' to 9,920'). The pay zone was determined according to the following cut-off values: effective porosity > 0.03, water saturation < 0.7, permeability > 300 md, and TOC < 10. Across the primary objective, the average effective porosity, water saturation, permeability, TOC, and MBI are 2.3 %, 64%, 748 μD, 3.21 , and 0.19, respectively. The range of Young Modulus, Poison Ratio, and MBI indicate a good ability of fracturing characteristic for this section. The OOIP of the target zone is 2.3 MMBBL. In the best case for the primary zone when the fracture height is greater than 80', more recoverable oil will be gained. Based on the movable hydrocarbon in the interval (cut off $\frac{s_w}{s_{xo}} < 0.7$), rock mechanical properties (such as Young modulus, poisons ratio, and brittleness coefficient), and placement of hydraulic fractures across the horizontal well (9,780' placement depth), the chance of having a good production from this section of the reservoir is highly possible.

CHRONOSTRATIGRAPHIC EVOLUTION OF THE PENNSYLVANIAN-PERMIAN EASTERN SHELF OF THE MIDLAND BASIN WITHIN STERLING AND COKE COUNTIES, TEXAS

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The Permian Basin is a hydrocarbon province located within west Texas and southeastern New Mexico. The Midland Basin comprises the eastern half of the greater Permian Basin and formed from subsidence resulting from the Late Paleozoic suturing of Pangea. The resultant strata filling the Midland Basin are the net accumulation of carbonate and clastic sediments as the shelf prograded. The focus of this project is to compare published progradation models of the Midland Basin to structure maps developed from biostratigraphic zone tops in wells drilled in Sterling and Coke Counties.

All maps were compared to the youngest recorded unit, the Leonardian, which provides the best fit to the published comparison model. The Wolfcampian, the Strawn (Desmoinesian), and the Canyon (Missourian) demonstrate aggradation followed by progressive progradation of the shelf preceding Leonardian time. Mapping of the Lower Strawn illustrates an east-to-west dipping ramp, whereas the Upper Strawn indicates migration of shallower structural levels westward and the initial development of a shelf-slope system. The younger Canyon aged surface displays eastward migration of the shelf system within western Coke County. Aggradation occurred from the Lower Strawn to the Canyon. By the Wolfcampian, the shelf edge had nearly prograded westward to the middle of Sterling County, and by the Leonardian the shelf edge was at a position equivalent to our comparison study. However, note that further detail is present in the structure maps developed in this study than the comparative study, which may highlight specific shelf sediment by-pass thoroughfares for sediments to the deeper Midland Basin. Overall, the eastern shelf of the Midland Basin is observed as migrating from the middle of Coke County in the Lower Strawn (Middle Pennsylvanian) to the western portion of Sterling County in the Leonardian (Middle Permian), which is consistent with previously published models of the basin.

SEISMIC MAPPING OF SEDIMENTARY STRATA AND FAULTS IN THE MUSTANG ISLAND FEDERAL LEASE AREA OF THE GULF OF MEXICO

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This study focuses on sedimentary rocks in the Mustang Island Area located in the north-western part of the Gulf of Mexico (GOM). Along the northern margin of The Gulf of Mexico, a number of growth faults run parallel to the shoreline. Previous studies suggest that occurrence of these faults is related to salt diapirs that are found in the Gulf Basin, but very few salt structures have been reported in the Mustang Island area. The data used for this study area consists of a grid of 33 2-dimensional seismic lines sections obtained by from the CGG, velocity survey data from 4 wells, and fossil records from 4 wells from the Data Processing Services of the Offshore Division of Houston TX. These thirty-three migrated seismic cross sections are interpolated. Four Subsurface seismic sediment horizons and 3 faults were identified on the seismic sections. Their depths were estimated from the relationship between seismic travel time and depth observed in the velocity survey data. The ages of the strata were estimated from the fossil records. The geometry of the horizons and the faults was digitized to yield a 3-dimensional surface model in the geographic information system software of the Mustang Island East Addition area. The 3D model gives insight about the stratigraphy of the area and how subsidence of the basin has affected faulting and the movement of salt and shale diapirs. Shallow (< 2000 m) sediments in my study area are heavily dissected by a number of parallel growth faults, and they seem to have been caused by diapiric movement of a deeper structure. Based on the available data alone, it is difficult to determine whether the diapir is salt or shale. The latter is somewhat likely because a previous study nearby suggests occurrence of a shale diapir.

ANALYSIS OF LUNAR SUBSURFACE HEAT FLOW DATA

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The Apollo 15 mission made heat flow measurements on the moon in 1971 through 1977. Dr. Marcus Langseth was responsible for processing and analysing the measurement data then, but he left a large volume of data left unprocessed. After his death in the 1990s, there wasn't a computer program left to analyze the data from the Apollo 15 Heat Flow probes. The purpose of my research was to reconstruct the data processing algorithm from papers published in the late 1960's and early 1970's found in The National Archives of Ft. Worth. The

algorithm was then used to process data from April 15, 1975 and was validated by comparison to Dr. Langseth's original interpretation of his processed data. A complete and working algorithm will allow the remaining unprocessed data to be processed and interpreted.

FRACTURE ANALYSIS AND STRESS ORIENTATIONS IN SLOW SPREADING OCEANIC CRUST, ATLANTIS BANK, SOUTHWEST INDIAN RIDGE

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In the Southwest Indian Ridge, Legs 118/176 and 179 cored Holes 735B and 1105A, respectively. The two holes lie roughly 1.2 km apart in the Atlantis Bank, an ocieanic core complex that exposes lower crustal and upper mantle rocks bound on the east side by the Atlantis II Transform. The Atlantis Bank is a 12 m.y old gabbroic massif that sits roughly 90 km south of the current ridge and 3km above average seafloor of similar age [1]. Core samples from Hole 735B were successfully collected from 0-1500 meters below sea floor (mbsf), and from Hole 1105A between 0-156 mbsf. Logging was completed over the intervals of 95-595 mbsf and 26-156 mbsf, respectively. The Formation MicroScanner (FMS) logging tool was used to analyze resistivity changes along the depth of the borehole. Changes in resistivity throughout FMS logs can show the presence of fractures since they are more conductive, and their geographic orientation, something that cannot be easily done only using core samples.Fracture data of the interval 90-160 mbsf was plotted on lower hemisphere equal area steronets in order to analyze potential correlation between the two holes and potential plaeo stress field orientation. 164 fractures were plotted from Hole 735B and 91 fractures were plotted from Hole 1105A. Each plot depicts a set of conjugate fractures present within the complex. Conjugate fractures in Hole 735B strike in the NW-SE direction, and dip steeply NE and SW. Conjugate fractures in Hole 1105A strike W NW- E SE, and dip moderalty N NE and S SW. Baines et al. [1] suggested that high angle normal faults oriented at a high angle to the spreding ridge were dues to local stress reorientation during transtension, common in weak transform faults (i.e., Atlantis II Transform). This would predict that the least compressive stress is oblique to to extension and the ridge, which is inconsistent with the results here, which suggests the orientation of the least compressive stress is low angle, near horizontal.

[1] Baines et al. (2003) *GSA* ***31***, 1105-1108

THE PABZT PROJECT: PERMIAN BASIN ARCHIVAL OF BIOSTRATIGRAPHIC ZONE TOPS

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In the Fall of 2011, the Department of Geosciences received a donation of biostratigraphic reports from wells drilled in the 1930's to the early 1970's within the greater Permian Basin region. These reports provide depth to the tops of numerous biostratigraphic zones and thus provide a means to spatially map out chronostratigraphic surfaces within the region. The PABZT (Permian Basin Archival of Biostratigraphic Zone Tops) Project was undertaken to digitally capture this data and provide a means to spatially manipulate with GIS.

To date, the project is approximately ~15% complete with 18 out of 126 counties completed. Total wells contributing to the current database is 1025 and largely centers on the northern and eastern rims of the Midland Basin. Highlights of the project so far, include illumination of the eastern shelf in early Permian time and the middle to late Pennsylvanian development of the Horseshoe Atoll. Future goals of the project are to: 1) complete the archival of the biostratigraphic horizons from each county in the collection and 2) build a searchable, online, spatially manipulatable database for quick construction of specific biostratigraphic horizons within the greater Permian basin region.