



Undergraduate Student Researchers on Horse Ridge overlooking Alamogordo, NM. (left-to-right: Trent Jackson, Amanda Rivera, Aline Blasizzo, Hannah Cunningham, and Dalton Walker)

# 10th Annual Department of Geosciences Research Day Abstracts Program



TEXAS TECH UNIVERSITY  
College of Arts & Sciences™

Department of Geosciences

**Department of Geosciences  
Texas Tech University  
Research Day 2016  
May 11<sup>th</sup>**

Welcome to the 10<sup>th</sup> Annual Department of Geosciences Research Day.

The program this year presents 33 abstracts from faculty, graduate and undergraduate researchers covering a wide variety of topics highlighting ongoing research within the Department of Geosciences. Note 25 abstracts are first authored by geoscience undergraduates. 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 Petrophysical 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.

Whiteface Elementary School has returned to present some of their fine research. Young researchers from Whiteface typically do very well at STEM competitions and our venue is a great place for them to practice scientific communication. Please make sure you stop by and visit their poster.

The communication division from the President's Office will be stopping by to visit. Please take a moment to talk with them and let them know what research day is all about.

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. The plaque is in the second floor display case, 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 and Volumetric Analysis of an Unconventional Reservoir: The Wolfcamp Formation of the Midland Basin, Texas**

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The Wolfcamp Formation extends from 9145' to 10121' in Midland Basin well #1-5399. The formation is divided into the Wolfcamp A (9145' – 9416') and Wolfcamp B (9416' – 10121') zones. Although initially the Wolfcamp Formation was considered a source rock due to its high shale content, recent advances in production techniques makes the formation a viable tight-oil reservoir. A petrophysical analysis was conducted using a provided complete well log suite to calculate the original oil in place (OOIPstb) within the Wolfcamp Formation. utilizing a 960 acre drainage and a CMR porosity log with 3ms cutoff; reserves were calculated to be 44.26 MMbbl for the Wolfcamp A zone and 93.35 MMbbl for the Wolfcamp B zone. Accounting for calculated geomechanical properties of the formation, the optimal depth for a horizontal well is proposed to be 9,594'. Assuming a total fracture height of 300' (from 9,444' – 9,744') the OOIPstb is estimated to be 22.18 MMbbl, of which 776,287 bbl is recoverable (assuming the 3. 5% average recovery rate for oil in the Wolfcamp Formation).

## **Petrophysical Evaluation of the Wolfcamp Formation.**

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The Wolfcamp Formation is a highly productive oil and gas reservoir that occurs in both the Midland and Delaware Basins of the Greater Permian Basin. Horizontal wells placed in the Wolfcamp have recently made this reservoir one of the most productive and highly drilled formations in the entire Permian Basin. In the Midland Basin, the Wolfcamp is primarily a shale interbedded with sandstone and limestone and is divided into four main units: A, B, C and D, and ranges from approximately 1,500 to 2,500 feet thick throughout the basin [1].

A full well-log suite was given for analysis from a Wolfcamp horizontal well drilled in the Wolfcamp A & B in the Midland Basin. The raw log data was calculated with Microsoft Excel (2013) and plotted by using Techlog by Schlumberger (2013). The calculations included: (1) Total Organic Carbon (TOC), (2) Vitrinite Reflectance (Ro), (3) effective porosity ( $\square_e$ ), (4) OOIP using four different porosities ( $\square_{bit}$ ,  $\square_{3ms}$ ,  $\square_{10ms}$ , and  $\square_{100ms}$ ), and lastly, (5) geo-mechanics (Poisson's ratio ( $\square_\square$ ), minimum closure stress ( $\square_{Hmin}$  psi), and Young's Modulus (E)).

The OOIP was calculated using two differing methods, one from CMR log data with differing cutoffs, and the other from bitumen corrected porosity, which is calculated from vitrinite reflectance. One of the main discussions in this project is therefore concerning which of the OOIP calculations is most reliable. The basis of this discussion is what pore diameter each of the porosities represent, because it is important to know how small can the pores can be and still produce hydrocarbons. It is impossible to know this for certain without necessary information regarding wettability, relative permeability and capillary pressure, but there is likely a correlation between the pore size and permeability.

For this project we have placed the lateral at 9325' based upon: (1) Lithology; where the reservoir contains more calcite and is easily fractured. (2) Resistivity; where there is a good invasion profile, indicating higher permeability (3) Geomechanics; it is desirable to have a high brittleness coefficient in order to fracture the reservoir, and a relatively low minimum closure pressure. (4) OOIP; the amount of calculated OOIP should be acceptable. (5) Porosity; the porosity should be acceptable.

[1] Friedrich, M. (2013) URTEC, 1461-1468.

## **Trace and rare-earth element signatures in calcite from rocks in the Seiland Igneous Province, Northern Norway igneous**

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The Seiland Igneous Province is a large (~5000 km<sup>2</sup>) intrusive body that occupies the western portion of the Kalak Nappe Complex, northern Norway. The Brevikbotn carbonatite was emplaced at 574 ± 5 Ma (Roberts et.al 2010), preceding a major period of ultramafic to mafic magmatism. Despite the rare nature of carbonatites at the earth's surface (<1%), they are relatively common in the Seiland Igneous Province; accounting for approximately 5% of the regions surface exposure. Moreover, the Seiland Igneous Compelx was metamorphsed during Scandian (Caledonian) metamorphism, and therefore may be studied to elucidate the textural and compositional response of carbonate minerals to post-magmatic processes.

Several carbonatite samples from the Brevikbotn Carbonatite were petrographically described, and carbonate minerals characterized using optical CL and BSE imaging. Selected carbonate grains were compositionally analyzed by EPMA, and trace element abundances were measured by LA-ICP-MS.T

The samples are silico-sövites based on their coarse-grained nature and calcite abundace, although this nomenclature is not universally accepted. The appearance of rims and ternary boundaries between calcites are relatively common among larger, subhedral grains. Well rounded, blebby grains are less common and texturally homogenous. Differences in textural characteristics of calcite do not correlate with changes in major or trace element abundances with the exception of Sr, which generally displays higher values at grain cores, and lower abundances close to ternary grain boundaries. Compositionally, the calcite contains very low MgO and FeO. Chondrite normalized REE patterns generally show LREE enrichment between 100 and 1000x chondrite, with no significant anomalies. The normalized REE patterns have negative slopes, sometimes with flat LREE profiles and are characteristic of calcite in other non-REE mineralized carbonatitese (e.g. Aley). However, the flat to humped LREE to MREE pattern has been reported for carbonatites that underwent post-magmatic hydrothermal recrystallization (e.g. Bear Lodge), and may represent a metamorphic-hydrothermal signature in calcite.

# Modern Log Analysis versus “OLD” E-LOG Method Permian 3<sup>rd</sup> Bone Springs Sandstone: Southeast New Mexico.

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In 1956 at a meeting at the University of Kansas Tixier put forward a technique called Maximum Producing Oil Index [Y]. The equation is listed below:

$$Y = (R_{mf}/R_{xo})^{0.5} - (R_w/R_t)^{0.5}$$

Maximum Producing Oil Index [Y] represents the amount of oil per unit volume which is displaced by mud filtrate (Tixier, 1956). Therefore Y is Mobile So<sub>h</sub>, and Mobile OOIP<sub>stb</sub> is:

$$\text{Mobile OOIP}_{stb} = (7758 \square Y \square h \square \text{Area})/\text{BOI}$$

[Note: NO Porosity or RHS Needed]

Log analysis of a Permian 3<sup>rd</sup> Bone Springs SS was done using a modern logging suite that includes: GEOCHEM (ECS), CMR, and Triple Combo logs plus Pyrolysis S1 Data. The results from these analyses [OOIP<sub>stb</sub>/160acre with a BOI of 1.4] are listed below:

Total Volumetric: 9.7mmbo

Volumetric: 6.3mmbo [T<sub>2</sub>>10ms] 3.2mmbo [T<sub>2</sub>>100ms]

KSDR > 300nD 2.8mmbo

Volumetric: 4.1mmbo [Bitumen Corrected]

Pyrolysis S1: 4.9mmbo

The resistivity log in this well is a High Resolution Laterolog Array-Rxo therefore zones in the 3<sup>rd</sup> Bone Springs SS that have been invaded can be delineated by the presence of hydrocarbon resistivity invasion profiles (i.e. HRLA<sub>5</sub>>HRLA<sub>2</sub>>Rxo). In order to define the better invaded zones, only zones where HRLA<sub>5</sub>>1.3□HRLA<sub>2</sub> and HRLA<sub>2</sub>>1.2□Rxo where used in the calculation of [Y] and Mobile OOIP<sub>stb</sub>. The results are listed below:

Mobile OOIP<sub>stb</sub> [Y]: 2.7mmbo

The lower Volumetric OOIP<sub>stb</sub> [T<sub>2</sub>>ms], OOIP<sub>stb</sub> [bitumen corrected], OOIP [Pyrolysis S1], and OOIP [Y] compared to Total Volumetric OOIP<sub>stb</sub> indicate the importance of OOIP calculations based on measurements of mobile [free hydrocarbons] hydrocarbons.

The Maximum Producing Oil Index [Y] method may be an addition method to determine Mobile OOIP<sub>stb</sub>. However, the Maximum Producing Oil Index [Y] is only valid if the zone being analyzed has been INVADDED. Therefore, the method will limited to salt mud resistivity logging suites, because invasion is very difficult to verify in hydrocarbon-bearing reservoirs with fresh mud logging suites.

## Textural analysis and EPMA geochronology of monazite in metapelites from the thermal aureole of the Ballachulish Igneous Complex, Scotland

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Monazite with a variety of textures and forms is documented in metapelites in the thermal aureole of the Ballachulish Igneous Complex. Grains were characterized by BSE imaging and element mapping, and based on textural complexity, analyzed by EMPA.

Monazite from Leven Schist show little variability in the size and shape along the temperature gradient. Compositional mapping show multiple textures that include patchy zoning, curvilinear domain

boundaries, and core-mantle-rim textures. Samples from the lower temperature samples in the Appin Phyllite are small, discrete and rounded in form. With increasing temperature some grains become slightly larger, are found in clusters, and a bimodal size distribution develops. In the Creran Succession, at increasing temperatures, the occurrence of monazite clusters decreases and the few grains that occur display dissolution textures on grain edges.

Comparison of textures to experimental work products, suggests that the decrease in grain size and dissolution textures in the Creran Succession is compatible with the presence of a fluid with hard anionic ligands present (e.g. S, F). Meanwhile the textures in the Appin Phyllite and Leven Schist are similar to those predicted by dissolution-reprecipitation reactions in the presence of more alkaline fluids.

EPMA trace element analysis of four samples from the Leven Schist led to the identification of four age populations: 470.5 ± 5.7 Ma, 450.7 ± 3.5 Ma, 430.7 ± 5 Ma, and 413 ± 3.3 Ma. By comparison with the literature the 470 Ma and 450 Ma populations are interpreted to represent regional metamorphic events. The Ballachulish Igneous Complex and its associated thermal metamorphism are dated between 421-427 Ma. The 431 and 414 Ma populations are most probably correlated with emplacement of the Ballachulish Complex, and subsequent hydrothermal circulation and metasomatism and during cooling, which is compatible with textures observed in monazite.

## Effects of Colloidal Silver, Probiotics, and Xylitol on Bacterial Biofilms: In Vitro and In Vivo Investigations

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STEM Research and Experimentation Team “Silver Bullet,” Seventh Grade Ecybermission Competition

Chronic wounds have become a significant health issue and a \$50 billion business in the United States. With an aging population and a steep rise in diabetes and obesity, heartbreaking wound complications can result in blood clots, heart disease, and amputation. The goal of cost effective ways to heal wounds in a world with antibiotic-resistant bacteria was the team challenge. Research and interviews led to experiments using xylitol, probiotics, and colloidal silver as possible ways to attack biofilms in chronic wounds. The team tested the effectiveness of these materials individually and created composite materials. In vitro tests used Petri dishes of nutrient agar inoculated with airborne bacteria and colonies from direct contact. The results identified colloidal silver as the material with the largest zone of inhibition and greatest ability to fight bacteria. On treated discs, bacteria could not form at all, and in tests with established bacterial colonies, silver fought back. It was the most cost effective healing substance at approximately two dollars per application, as opposed to much higher costs for gold nanoparticle ointments or oxygen chamber treatments.

During in vivo invertebrate testing, silver again showed great promise by speeding cell growth and closing wounds on earthworms. When silver was injected into hydrogel, a water-based pad, its potential was fully realized as a bandage with benefits of moisture, comfort, healing properties of colloidal silver, and affordability. Working with university research scientists, this STEM solution is designed to benefit the 6.5 million people suffering from chronic wounds.

## **Petrophysical Analysis of Wolfcamp Formation (A and B).**

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The Wolfcamp formation in the Permian Basin is a world class play that is located in West Texas bordering New Mexico. A 7500 foot lateral will be placed within the Wolfcamp formation and will utilize the hydrocarbon potential of 960 acres within Wolfcamp units A and B. This Pennsylvanian to early Permian aged strata is composed of interbedded carbonate, clastic turbidites, and organic-rich shales. Simultaneous deposition of clastic sediments and organic-rich carbonates resulted in a hydrocarbon rich environment with conventional and unconventional reservoirs.

The analysis for this assignment presented data using a full well-log suite that included geochemical data. Calculations were performed using Microsoft Excel and Techlog (2015) by Schlumberger. Assigned calculations included (1) vitrinite reflectance (2) total porosity (3) effective porosity (4) total organic carbon (5) variable matrix analysis (6) OOIP using variable matrix analysis (7) bitumen corrected OOIP (8) T2 cutoff OOIP (9) rock geomechanics.

In order to decipher where the lateral for our well will be placed OOIP at 10ms, GR values, overlap of shallow, medium and deep resistivity, geomechanical data and permeability values greater than 1 $\mu$ D were all considered. Through well log analysis and geomechanical calculations, the optimal position for the placement of our lateral is at 9560' with a fracture propagation window of 300ft, placing the top of the fracture at 9410' and the bottom at 9710'.

## **Reconnaissance-Level Discharge Measurements in the Context of a Gain-Loss Study for the North Fork Double Mountain Fork Brazos River near Lubbock, Texas, October and December, 2015.**

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The primary objective of the City of Lubbock's strategic 100-year plan is the development of a risk-balanced portfolio for municipal water supply. Currently (2016), the Water Utility of the City of Lubbock, Texas, receives water from Lake Allen Henry, Lake Meredith, well fields in Roberts and Bailey Counties. The Utility has a state permit to reclaim treated water-water effluent at the junction of County Road 7300 (CR7300) and the North Fork Double Mountain Fork Brazos River (NFD MF). Effluent (Outfall 001) enters the NFD MF at Farm Road 400 (FM400) and is conveyed along a river reach about 2.7 miles to CR7300. The purpose of this study is to summarize results from a reconnaissance-level evaluation of the gain-loss potential of the bed and banks of the NFD MF reach (FM400 to CR7300). Ultimately, permitted withdrawals could be less than effluent inputs if the reach is a losing reach and not augmented if the reach is otherwise gaining. For this study, wading discharge measurements were made at three locations: directly

upstream of Outfall 001, about 40 feet downstream of Outfall 001, and immediately downstream of the CR7300 crossing. Discharge measurements were replicated on October 3, 2015 and on December 10, 2015. Analysis in the form of a paired t-test indicates no statistically significant difference between same day discharge replicates. In summary, there was a mean gain of 1.84 ft<sup>3</sup>/s for the 2.7-mile reach for October 3, 2015 and a mean loss of -1.62 ft<sup>3</sup>/s for December 10, 2015. Combining these two means as another mean suggests a gain condition of 0.11 ft<sup>3</sup>/s. Steady state and seasonal impacts are not controlled for with these limited data.

## **Isotopic Composition of Organic Carbon across the K-T Boundary in the Black Peaks Formation, Big Bend National Park, Texas.**

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A negative -1.5 to -2‰ carbon isotope excursion has been identified in sediments across the Cretaceous-Tertiary (K-T) boundary all over the world. The present study was undertaken to determine if a similar excursion occurs at the K-T boundary in the Black Peaks Formation in Big Bend National Park. A negative excursion was not found; instead values appear to gradually increase from the base of the sampled interval to the top, from a low of about -28‰ to a high of about -24‰. If the excursion is present here, higher resolution sampling may be necessary to detect it.

## **A Carbon Cycle in the Jim Bertram Lake System.**

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The Jim Bertram Lake system is a series of six lakes that run through the east side of Lubbock to provide the city with recreation facility and runoff control. Created in the 1970s, the JBLS uses reclaimed wastewater that is first used for agricultural purposes and then pumped to an outflow pipe at Lake 1. Very high nitrate levels of the discharged water rapidly decline by algal bloom. This study focused on the carbon cycle in the lake system to understand the algal growth that occurs with high nitrates. The water samples collected in 2012/2013 [1] were successively filtered and algal solids on the filters were recovered. The carbon contents of the algae were determined and compared to the dissolved inorganic carbon (DIC) present in the water and nitrogen trends. The results from the algae analysis show that the ratio of carbon to nitrogen stays mostly constant with increasing distance from the outflow pipe. The carbon contents from the algae increases, while the DIC in the lake system decreases. Thus, the ratio of algal carbon to DIC increases with distance. [1] Quintanilla. (2013).

## **Velocity Modeling of the Crust and Moho at the Matador Arch.**

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The Moho at the Matador Arch area is expected to be approximately 45km deep. Data from the MSTX permanent broadband seismic station in Bailey County, Texas was processed to create receiver functions. The receiver functions are then mapped and grouped based on their back azimuth and great circle arc origins for seismogram stacking.

Simplex and genetic algorithms (Matlab 2014) were used to fit the clustered seismograms to pre-established velocity models. User-controlled parameters are used to limit excessive variability and allow for a variety of fits per model per algorithm. These include a maximum and minimum corridor along the input model, penalties for large negative velocity jumps and for limit on the allowable number of sharp velocity changes.

This process produced several velocity models that suggest the moho is at the target depth. However the models do not display a reliable degree of consistency and will require further parameter and input model refinement and more trials to more accurately match the stacked seismograms. The addition of newer MSTX data and additional stations' data may also yield more accurate results.

## **Dust in the Wind: A study on the origin, composition, and health effects of particulate matter in Lubbock**

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Dust storms are a common occurrence in semi-arid climates such as that present in West Texas. The wind blows in dust and other forms of particulate matter, mineral dusts, bacteria, pollen, and spores of fungi. Weather reports often contain information on the air quality because these particulates can affect health. With collaboration between the Departments of Biology and Geosciences at Texas Tech, an ongoing research study was designed to determine not only the bacteria and fungi present in the blowing dust, but also from where the microbes and the blowing dust originated. Furthermore, an independent study was conducted to consider these factors, as they are significant to asthma. While not a direct cause, quartz mineral particulates are a significant irritant of asthma that is common in West Texas where dry climate farming takes place. Control samples were collected once a month during a calm day, while experimental samples were taken when the wind speed exceeded 25 km hr<sup>-1</sup> causing blowing dust from the south, west, southwest or northwest. Samples were collected between 4:00 and 6:00 pm central time. These conditions were picked because they are likely to cause "blowing dust". Samples of bacteria and fungi were obtained by holding open agar plates into the wind at ground level and approximately 200 feet above ground. The fungi and bacterial counts were tested within microbiology lab to connect with the atmospheric conditions. For the atmospheric portion of the study, (Hybrid Single Particle Lagrangian Integrated Trajectory Model) HYSPLIT back trajectories were created for all sampling days at three levels of the atmosphere (0m, 250m, 500m) and extended back 48hrs in time. These back trajectories of the parcels of air give insight into where the air coming into Lubbock is originating from, which is not always the direction of the wind. Season, time of day,

temperature, elevation, wind speed, and wind direction are factors that affect the microbes and fungi present in air at any given time. Both control and testing days from the roof had significant amounts of asthma causing fungi in the air however, on testing days there was more *Cryptococcus sp.* and *Cladosporium cladosporioides* present than on control days. Also, on the ground, there were much higher levels of *Alternaria alternata* overall. By connecting the types of particulate matter to the direction of the back trajectories and the wind, we can gain a better understanding of how certain conditions affect health. Future research hopes to address health impacts in connection with the atmospheric conditions and the collected bacteria and fungi.

## **Investigation of the relation between observed field measurements and theoretical discharge for a V-notch weir at USGS streamflow-gaging station 07295500 Tierra Blanca Creek near Umbarger, Texas, 1942–2015**

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USGS streamflow-gaging station 07295500 Tierra Blanca Creek near Umbarger, Texas contains a sharp-crested V-notch weir that was built in 1942 and has been used to measure and monitor stream discharge. Multiple discontinuations of the site have led to substantial time gaps in data; this irregular operating timeline combined with a long-incorrect gage datum, the station's operation through multiple entities, and a questionable validity of past measurements because of a lack of detailed information has led to quite general questions (curiosity) about the weir's functionality (performance). The purpose of this study is to examine past measurements and compare them to theoretical solutions under the same conditions for assurance of proper functionality of the weir. Calculated and previously recorded values were inserted into the sharp-crested 90 degree V-notch discharge equation [ $Q=Cd*(8/15)*\sqrt{(2g)*\tan(\theta/2)*H^{5/2}}$ ] with the intent of finding an empirical coefficient of discharge for each measurement. Some 105 measurements were used in this study, which were found to have a considerable range of observed coefficient of discharge, but an overall mean of 0.568. Because the theoretical coefficient of discharge for a 90 degree V-notch weir is 0.578, it was concluded that the weir is properly functioning as indicated by theory; however, the source of the observed coefficients were not confirmed.

## **Petrophysical Study of the Wolfcamp Formation, Permian Basin**

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The Wolfcamp Formation, within the Permian Basin in TX and NM, is important due to its high potential for hydrocarbons. This area is one of the largest petroleum producing basins in the U.S. and has produced more than 28 billion barrels of oil to date. Our area of interest is within the Spraberry Trend southeast of Midland, Texas. Lithologies include low-permeability clastic sediments, carbonates, and shales that are

hydrocarbon charged and economic due to the overall thickness of the section [1].

This project was aided by the availability of a full well log suite including geochemical logs. To perform analysis, both MS Excel and Schlumberger's Techlog were used. Calculations in this project include: TOC, Vitrinite Reflectance, Effective Porosity, Clay Bound Water, Young's Modulus, Poisson's Ratio, Brittleness Index, and Minimum Horizontal Stress. OOIP was also calculated using multiple methods and a Sw cut-off of 0.4 to determine the most effective and accurate results.

All depths are examined for reservoir and completion quality criteria to place the lateral. Depths at 9,570 ft. and 9,800 ft. (located in Wolfcamp B) have the largest amount of movable hydrocarbons in place and acceptable brittleness to ensure successful multi-stage fracturing treatment. IPR analysis shows that the zone at 9,570 ft. is more productive as compared to 9,800 ft. and will therefore be the optimal location for placement of a lateral well. The 230 ft. difference between the two zones is not substantial in drilling expenses, although a basic economic analysis is presented in the poster.

[1] Scott L. Montgomery, David S. Sche. "Advanced Reservoir Characterization to Evaluate Carbon Dioxide Flooding, Spraberry Trend, Midland Basin, Texas (E & P Notes)." Bulletin AAPG Bulletin 84 (2000)

## **Tectonic Interpretation of Magnetic Anomalies in the Grapevine Hills Area, Big Bend National Park, Texas.**

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Aeromagnetic data for the Grapevine Hills area show significant variation in magnetic field intensity. Strong positive magnetic anomalies correspond closely to mapped positions of large bodies of gabbroic igneous rock – a laccolith at Grapevine Hills, and a sill to the northwest. The laccolith appears to be only the exposed part of a much larger intrusive rock body underneath the southern part of the map area. Northwest-trending Basin & Range faults that cross the area show varied offset of the magnetic anomalies, probably because of variation in vertical displacement. One fault that appears minor in the surface geology may have much more significant offset on the basis of marked change in magnetic field intensity where the trace of the fault passes under alluvial cover. An unusual east-west trending fault that crosses the area does not show evidence for the expected right-lateral offset in the magnetic anomaly, if structural modeling of the structure was correct. Instead, there is a reduction in field intensity across the fault more likely due to vertical offset and thickening of the sedimentary rock section on the downthrown side of the fault.

## **Permian and Pennsylvanian Evolution of the Central Basin Platform in Upton and Crane Counties**

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The Permian Basin Province, located in west Texas and southeastern New Mexico encompasses multiple structural highs and basins. This

project focuses on a structural high called the Central Basin Platform (CBP). The CBP divides the Permian Basin Province into the Midland and Delaware Basins. Over time, the CBP evolved due to uplift from compressional forces, faulting, and subsidence, experienced during Permian and Pennsylvanian time. Structure maps created from biostratigraphic well reports were used to map shelf migration from Atokan to Wolfcampian time. Progradation and regression, from fluctuating sea levels, resulted in spatial variation of the shelf edge, defined by zone of maximum flexure on each map. Shelf edges were then analyzed and compared to each other to interpret the regional geologic environment, displacement among time periods, and potential global interpretations.

## **AN ELECTROMAGNETIC CONDUCTIVITY ANALYSIS OF FOCUSED RECHARGE BETWEEN PLAYAS & THE OGALLALA AQUIFER IN THE SOUTHERN HIGH PLAINS.**

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Playas are known to increase the speed of hydraulic recharge percolating from the ground surface to the underlying High Plains Aquifer. However, the specific flow path for this fast recharge is currently unknown, and to determine such a path, we measured electromagnetic conductivity beneath playas and generated 2D cross-sectional profiles therefrom. These profiles revealed elliptically-elongated, high-conductivity pockets beneath the Hezek zone of playas, a zone between the center and the annulus. As this location fits neither with a flow path directly beneath the playas' centers nor annuli, we eliminated potential models to conclude that the path of focused hydraulic recharge is across the subsurface caliche layer and down over the edges of caliche holes that exist, for chemical reasons, beneath the central and Hezek zones of playas. These conclusions imply that playas can be used for farm or ranch land without impeding the *quantity* of focused hydraulic recharge to the High Plains Aquifer.

## **Evolution of Basin Fill within the southern Palo Duro Basin in Northwest Texas**

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The overall goal of the Permian Basin Archival of Biostratigraphic Zone Tops (PABZT) Project is to consolidate tops of biostratigraphic zones in northwestern Texas. This will be accomplished by cataloging fusulinid data from well logs originally written in the 1950s-1970s and mapping it using Arcmap. The purpose of this particular report is twofold. Firstly, this report will map the biostratigraphic zone tops in Deaf Smith, Randall, Castro and Lamb counties and add their data to the PABZT project. Secondly, this report will use the data gathered to study the evolution of the southern Palo Duro Basin. The Palo Duro Basin was formed by the uplift of surrounding basement during the formation of the Ancestral Rocky Mountains in the Late Paleozoic. The basin is filled

primarily with Pennsylvanian and Permian age sediment. The rocks consist of sandstone, limestone, shale and evaporites associated with shallow marine, deltaic and tidal environments. Using fusulinid well data, we were able to create subsea surface maps of different biostratigraphic zone tops. Using these zone tops, well data and past research, we can evaluate the rocks deep beneath the surface. The zone tops in the Palo Duro Basin are all found to be deepening southward in varying degrees. Combining the subsea surface maps, the well data and past research, we can determine the evolution of the basin. The results presented here are consistent with the work described by others, including: 1) syn-orogenic Late Mississippian through Pennsylvanian clastic sedimentation; 2) development of a Late Pennsylvanian and Early Permian shallow sea; and 3) late stage evolution to an evaporative tidal environment in the middle Permian.

## **Petrography Of Mudrocks in the Cline Shale ('Wolfcamp D'), Pennsylvanian Eastern Shelf of the Midland Basin, Texas.**

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The Pennsylvanian Wolfcamp "D" or Cline Shale of the Permian Basin is a typical shale-hydrocarbon system in which the rock is the source, reservoir, and seal. The Cline Shale was deposited along the margin of the eastern shelf of the Midland Basin, and is one of the deepest targeted formations in the region. Samples of the Cline Shale were obtained from a core taken in the Amoco #1 Bever well in Garza County, Texas. Petrographic thin-sections of the samples exhibit two shale lithofacies: clay-rich siliceous mudstone, and mixed siliceous mudstone (using the Schulumberger sCore organic-rich mudrock lithofacies classification). The two lithofacies are dominated by clay, and vary primarily in the abundance of detrital quartz and mica silt, and in the abundance of carbonate bioclasts. Both contain trace amounts of pyrite and phosphatic skeletal grains. The high clay content of the Cline Shale typically leads to sloughing, and well perforation and completion problems.

## **STRAWN THROUGH WOLFCAMPIAN SHELF EDGE PROGRADATION OF THE NORTHEASTERN MIDLAND BASIN AND SOUTHEASTERN PALO DURO BASIN, KENT, DICKENS, AND MOTLEY COUNTIES, WEST TEXAS.**

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Throughout the late Paleozoic, deformation continued to shape the basins that are located in West Texas. Combined with subsea environments and subsidence, clastics began to fill these basins through gravity driven processes. Identification of fusulinid-biostratigraphic occurrences will highlight the various structural and environmental changes that developed within the Midland and Palo Duro basin. A "shelf edge" will identify the locations of clastics entering the basin and

determine which intervals contained a high amount of clastic input. The maps created through this research will describe the tectonic and sedimentary environment that occurred throughout the Strawn to Wolfcampian intervals.

## **TRANSITION OF THE MIDLAND BASIN TO THE MATADOR ARCH IN BAILEY, PARMER AND COCHRAN COUNTIES DEFINED THROUGH RECONSTRUCTION OF DEPTH TO FUSULINID BIOZONES**

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Fusulinid biozones for the Midland Basin define the depth to the tops of various chronostratigraphic surfaces within the Pennsylvanian and low Permian strata. The strata are continuous across the basin but is warped over structural highs on basin edges. Utilizing fusulinid biostratigraphy to create subsurface chronostratigraphic surfaces allows for more accurate subsurface mapping through the Midland Basin across the Matador Arch and into the southern Palo Duro Basin. Mapping these strata more accurately provides better regional control for economic play surface area for oil companies and will help with large-scale basin analysis projects. The Permian Basin province contains many geologic features such as the Midland Basin and Palo Duro Basin, which are primarily filled with Pennsylvanian, Permian and Triassic strata. Through three phases, we archived tops of fusulinid bio-zones picked by Hollingsworth, converted the well coordinates to latitude and longitude decimal degrees, and manipulated the chronostratigraphic tops (z-values) in X-Y space to produce structure maps which show the shelf edge through Strawn to Wolfcampian time. Results from the data provide a zone of maximum flexure of the surface, which can be interpreted to being the Matador Arch. The zone of maximum flexure was also found to migrate north through Bailey and Parmer county over time. This data concluded that the transition of the Midland Basin to the Matador Arch and into the southern Palo Duro Basin can be accurately located in Bailey and Parmer counties between Strawn to Wolfcampian time.

## **Rediscovery of the 'Antelope Flat' Volcanic Ash Bed, Caprock Canyons State Park, Texas.**

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An outcrop of an unknown ash bed was discovered in the Blackwater Draw Formation on John Haynes Ridge at Caprock Canyons State Park, in Briscoe County. This locality is about 13 miles southwest of the community of Antelope Flat, and almost certainly represents the 'lost' site described by Sidwell and Bronaugh in 1946. Based on stratification, ripple marks, and bioturbation found within the ash bed, it is clear that the ash was reworked and deposited in a shallow, low-energy subaqueous environment. A clay bed beneath the ash layer closely resembles the 'Randall Clay' soils found in modern playa deposits. A major-element analysis using X-Ray Fluorescence shows that glass in the Haynes Ridge ash bed is similar in composition to the 'Pearlette' family of ashes erupted from the Yellowstone Caldera in Wyoming, and not the Guaje ash erupted from the Jemez Caldera in New Mexico. Of the Pearlette ashes, only two are known to have reached Texas – the Lava Creek B (0.62

million years old) and the Huckleberry Ridge (2.02 million years old). The Huckleberry Ridge ash is probably too old to have fallen during deposition of the Blackwater Draw Formation, and it is very likely that the ash bed found on Haynes Ridge is the Lava Creek B.

## **THE EFFECT OF CHLORIDE VERSUS NITRATE ON THE SOLUBILITY OF PYROLUSITE.**

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Manganese oxides are widespread in the environment and are highly reactive. Manganese oxides play an important role in reactions such as the biogeochemical cycling of heavy metals, toxic trace elements and soil nutrients. Such reactions are mediated by the high solubility of manganese oxide phases. This study examines the solubility of pyrolusite ( $\beta$ -MnO<sub>2</sub>) in sodium chloride and sodium nitrate media. Pyrolusite was selected for study as it is the most stable and abundant MnO<sub>2</sub> polymorph.

A commercial pyrolusite sample was used in all experiments. Prior to use, the sample was washed and characterized extensively. Characterization included XRD, TGA, and SEM imaging. The XRD confirmed that the sample was pure, crystalline pyrolusite. The SEM images showed that the sample has a blocky morphology.

Parallel solubility experiments were performed in NaCl and NaNO<sub>3</sub> media, at 0.3 m ionic strength. Each suite of experiments (NaCl or NaNO<sub>3</sub> media) comprised 7 solutions at varying pH, ranging from pH 3 to 9.4. All experiments were conducted in duplicate. The solubility experiments were performed at room temperature (23 °C) by reacting 0.8 g of pyrolusite with 30 g of aqueous solutions, in air-tight syringes that were placed on a rotating rack. The syringes were sampled at discrete intervals, with the initial sample taken after one hour. At each sampling 1 g of solution was filtered through a 0.2  $\mu$ m membrane filter, the sample was acidified with HNO<sub>3</sub> for later ICP analysis. At the fourth and fifth sampling an additional 1.5 g sample was withdrawn for pH measurements. The concentration of dissolved manganese was determined by ICP analysis. The experimental results show that pyrolusite dissolves at similar rates in the NaCl and NaNO<sub>3</sub> solutions. Additionally, it was observed that with increasing time the concentration of manganese in solution increased. Conversely, the concentration of manganese decreased as pH increased. At pH values above 5 the concentration of manganese remained nearly constant.

## **The mineralogical and petrographic study of a High Plains meteorite.**

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Meteorites are the oldest, most primitive materials known and are key to deciphering the origin and evolution of the solar system and Earth. Texas is a particularly productive place in terms of meteorites, especially flat and highly cultivated Southern High Plains. Meteorites fall into three main groups: stony, iron and stony-irons. Of those the

stony are the most primitive (unaffected since their formation). The stony fall into two classes: chondrites, which contain round objects called chondrules, and achondrites that do not.

I investigated a meteorite, informally named Red Raider, in order to determine its mineralogy and petrography. The rock arrived at the Texas Tech Geoscience Department in September 2015 for identification. This large stone, 5.703 kg, allowed a unique opportunity for extensive study. My preliminary findings are that this specimen is a piece of the well-known Brownfield and Plainview meteorites. Prior research classified these meteorites as H-type ordinary chondrites. My goal was to classify the new rock and see where it fit. I studied Red Raider using petrographic and integrated XRD and SEM techniques.

A back-scattered electron (BSE) map helped identify the types of chondrules present in the sample. Three types were observed: porphyritic, barred, and radiating. SEM images also reveal minor plagioclase laths within the interstices of the porphyritic chondrules as well as exsolution-like textures in the radiating pyroxene chondrules. The modal abundances (vol%) of silicate minerals were obtained through XRD analysis. The mineral assemblage includes 65.5% pyroxene (mainly orthopyroxene), 34.4% olivine (mainly forsterite), and 0.045% plagioclase. Overall, Red Raider is 60-70% chondrules, 15-20% metal, and 5-10% contributes to an opaque inter-chondrule matrix.

The mineralogy and petrography suggest that Red Raider is a so-called H5 ordinary chondrite. The possibility of Red Raider being a piece of the 1964 Brownfield H5 ordinary chondrite or the 1917 Plainview H5 ordinary chondrites is contingent on two factors: the exact location where it was found and a more detailed matching of chemical signatures. The high abundance of chondrules including the presence of a mega-chondrule will make Red Raider an ideal sample in pursuing further work on chondrule formation and textures.

## **MOHO TRANSITION POINT THROUGHOUT NORTHEASTERN COAST OF THE GULF OF MEXICO**

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10,411 events were gathered from twenty-five stations located primarily in state of Louisiana and a small part of East Texas. These events all were collected from Incorporated Research Institutions for Seismology (IRIS). All events will be processed using the receiver function method in which consisted of cutting, rotating, resampling and quality controlling the data. The receiver function method will help reduce any noise that is attached with seismic events, and by removing the noise it will display the structure that is under the seismic station. A velocity model was then developed to display a 2D model for depth of sediment layers and depth of the Moho. Previous gravity models have been done in the field of study, which will then be compared to our research.

## **Using the Short-term Deployment of a Three-component, High Frequency Sensor Array to Produce a Receiver Function.**

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Using broadband seismometers is an expensive method of recording seismic events used to image Earth's subsurface. It is believed that there is a more cost-effective alternative in recording seismic activity that will produce the same quality of data as broadband seismometers. By deploying an array of high frequency seismometers for a short period of time, the data will produce receiver functions that are comparable to the long-term deployment of a broadband seismometer. This idea proposes that the array will also reduce the amount of noise that is associated with seismic recordings. Data taken from a short-term array of high frequency seismometers and also from a broadband seismometer (both located within the Muleshoe National Wildlife Refuge) were used to compute receiver functions for different back azimuths and great circle distances. The data collected by the short-term deployment of the high frequency array has shown to produce receiver functions with the same, or even better quality than receiver functions computed using broadband data. It is also shown here that the short-term deployment of an array of high frequency seismometers for eight days can record enough useable events to compute a quality receiver function.

## **A New Approach to Monitor Air Temperatures Experienced by Patrons in Semi-Outdoor Environments**

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Environmental heat hazards during densely populated sporting events are a serious issue for players and spectators alike during the warm season. The spatial variability in heat exposure is unevenly distributed both within built urban areas, and unique microclimates develop within semi-outdoor environments, such as sporting venues. The purpose of this research is to compare direct, *in situ* measurements of air temperature ( $T_a$ ) and relative humidity (RH) within the Texas Tech Football stadium to temperatures monitored at nearby weather stations, which represent the outdoor ambient temperature (OAT). The two variables were measured by Hydrochrom and Thermochron iButtons, which are small devices (<20 mm diameter, <7 mm thickness, 3.3 g). 20 iButtons were evenly distributed at various locations within Jones AT&T Stadium in Lubbock, Texas from Sept 12–14<sup>th</sup>, 2016 in order to assess both the variations within a semi-outdoor environment, and the thermal comfort of the patrons. The locations were selected based on observing different exposures in the stadium, indoor and outdoor microclimates, amount of spectators, and height (field level versus upper levels). Temperatures measured from these iButtons were compared to OAT taken at 5min intervals. Both maximum and average  $T_a$  from the iButtons in the stadium were higher than those recorded at the airport weather station. The maximum and mean  $T_a$  for all iButtons were measured to be 48.9°C and 24.7°C, respectively, while those of the OAT were 36°C and 23.87°C respectively. Finally, we obtained data records of emergency medical services (EMS) calls and transports from the University Medical Center (UMC). Numbers and locations of EMS heat illness calls were related to the  $T_a$  and heat index values. This study demonstrates how  $T_a$  varies within a crowded semi-outdoor environment, and is higher than the OAT. Information gained from this research will provide insight into the varying temperatures of the stadium, heat exposure of patrons related to heat illness, and provides and improved understanding of design of semi-outdoor spaces and sun exposure may affect thermal comfort.

## **Origin of an Unusual Limestone Breccia Bed in the Boquillas Formation (Upper Cretaceous), Big Bend National Park, Texas.**

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A thin breccia bed in deep-water limestone in the Ernst Member of the Boquillas Formation records an unusual event that occurred during Late Cretaceous time (c. 100 Ma) in the Big Bend region of Texas. A meteor impact formed Sierra Madera astrobleme north of Big Bend at that time, and could have triggered deposition of the breccia bed. Whatever process was responsible, it ripped up clasts of the Boquillas limestone and transported them along the sea floor by traction transport along with an unusual mixture of broken shells and fish bones – particles that are otherwise very scarce in the Boquillas. Transport of the breccia was interrupted multiple times when very fine amorphous material settled out of the water column and blanketed over the breccia clasts. More breccia accumulated, and another layer of fine material settled out of the water at least three times. Major element geochemical data for these fine draping layers are inconclusive, but indicate that the amorphous material is some kind of silicate. Detailed study of this fine material may hold the key to determining the origin of the breccia bed.

## **An Analysis of the WBGT as an Accurate Predictor of Heat Stress in Climates of Contrasting Moisture Regimes.**

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Heat stress poses a health risk to athletes worldwide in almost every type of sport. A variety of factors dictate the heat stress of an environment, including: relative humidity, air temperature, wind velocity, radiant temperature from the surrounding environment, and physiological characteristics. This study examines the Wet Bulb Globe Temperature (WBGT) and how it differs in distinct climates, which may be due to contrasting moisture regimes. Climate data from the cities of Houston, Fort Myers, Phoenix, and Las Vegas were obtained from the National Solar Radiation Database over a period from 1990-2005. Houston and Fort Myers were deemed representative of moist climates, whereas Phoenix and Las Vegas were chosen to represent dry climates. The data was then filtered for days with a WBGT value of 32.3°C, a value considered to be the threshold for canceling an American Football practice. Four heat indices were calculated for each day of the filtered data: 1) COMFA human energy budget, 2) Humidex, 3) Mean Radiant Temperature, and 4) Universal Thermal Climate Index. An analysis of variance was performed on each index between groups of two cities.

Results indicate that different climates may reach the same WBGT value despite large differences in predictive factors of heat stress—such as radiant temperature or humidity—with numerous statistically significant differences found when comparing the indices in dry versus

humid locations. For example, analysis of the mean radiant temperature indicates that air and globe temperatures were higher in Phoenix than Houston or Fort Myers. Therefore, higher natural wet-bulb temperatures in Houston and Fort Myers enhanced the WBGT to be equal to that of Phoenix, which had higher radiant temperatures.

The findings indicate that there may be a need for adaptive models and thresholds for the use of the WBGT in dry climates. The WBGT was developed and tested in humid climates, thus this research supports previous evidence of a disconnect between WBGT as an accurate predictor of the impact of heat stress on human health in climates of contrasting moisture regimes.

## **A Fault Kinematic Analysis with Observations Pertaining to Fault Trends within the Core of the Arbuckle Anticline, Southern Oklahoma, USA.**

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The Arbuckle Anticline, located in the western area of the Arbuckle Mountains, is well recognized as an uplift from the Ouachita Orogeny. Previous work has documented the major structural features that characterize the deformation history of the Arbuckle Mountains. However, the smaller-scale structural features along Interstate 35 have mostly been overlooked in these studies.

The focus of this study is the core of the Arbuckle Anticline along Interstate 35 at Mile Marker 48. The methods used to analyze this outcrop include geologic mapping, panoramic mapping, kinematic analysis, and fracture analysis along the outcrop. Data from (Hessert, 2016 [1]) were used in conjunction with the data presented here to allow for compatibility comparisons between the core of the anticline and the limbs. The results are as follows: (1) Kinematic analysis from fault striae within the core show a greater occurrence of strike slip movement compared to dip slip movement consistent with reverse and oblique left-lateral strike slip motion and displacement; (2) The core contains the Ft. Sill Limestone interleaved with the Royer Dolomite in a previously unrecognized sequence of imbricate thrusts; (3) Shallowly plunging folds and fold hinges throughout the core indicate oblique left-lateral displacement and sinistral rotation (4) Both pre-folding and syn or post-folding fracture sets can be differentiated with the most notable syn or post-folding fracture sets being present within the core of the anticline (5) Structures along Mile Marker 48 are found to be kinematically compatible on an outcrop scale noting both sides of MM48 document significant left lateral displacement. There is also compatibility throughout the rest of the anticline as there is a notable shift in fault trends from dip slip movement to strike slip movement towards the core.

[1] Hessert, Jenna (2016), Master's Thesis: A Structural Investigation Of The Evolution Of The Arbuckle Anticline Related To The Ouachita-Appalachian Orogenesis. Texas Tech University

## **Evaluation of the TTU Weather Forecast System for Convective Forecasts at Different Lead Times.**

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Weather forecasts are chaotic, and it is difficult to pinpoint exactly what weather will happen, when, and in what location. The purpose of this project is to evaluate forecasts from the operational TTU deterministic weather prediction system of 8 different severe weather events from the 60-hour forecast down to the 6-hour forecast. The forecasts at different lead times will be evaluated through a comparison to radar data and will focus on location, magnitude, area affected, and mode of the event. The analysis was completed by analyzing archived forecasts and observations.

The study concluded that forecast models starting at 60-hours out are inaccurate, they randomly increase and decrease in accuracy as the event approaches, and there is a jump in accuracy as the event arrives. For the location, coverage, and magnitude metrics, the accuracy trend was similar, with increasing accuracy from 60 hours out to about 42 hours out, and a short accuracy decrease for 6 hours followed by another increase in accuracy. The analysis of the event mode had more rises and falls in accuracy. All of the studies showed a sudden increase in accuracy at the 6-hour forecast.

## **Hillslope Evolution in the South Prong Valley of the Little Red River, Caprock Canyons State Park, Texas.**

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The South Prong valley shows a change in hillslope profiles downstream from its headwaters to near its mouth. In its headwaters region, the valley profile is very narrow and steep, suggesting that the high stream gradient and more rapid rate of downcutting prevents cliff and bench topography from developing. Further downstream the valley floor broadens, the hillslope profile changes, and cliff and bench topography becomes pronounced. With increasing distance from the headwaters, the benches between free faces widen, and the valley floor continues to broaden, coupled with a gradual drop in elevation. The parallel slope retreat model appears to apply to this part of the valley. Below the point where resistant rock layers in the Dockum and Ogallala are removed from the drainage divides, the hillslope profiles are lower, and the slope decline model may apply.

## **Trace element signatures from calc-silicate rocks in the thermal aureole of the Ballachulish Igneous Complex.**

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The role of fluids in metamorphic processes is well documented, and their impact on accessory mineral texture development and trace element distribution, particularly in silicates, is increasingly well understood. In this study textures in metamorphic carbonates from the aureole of the Ballachulish Igneous Complex are correlated with CL response and trace element abundances to establish textural and compositional relationships in complexly zoned carbonate minerals.

Carbonate in samples consist of dolomite and calcite, while silicate portions are dominated by feldspars, and a mixture of neso- and ino-

silicate minerals. Low temperature carbonate assemblages are finer grained, with calcite forming very fine-grained aggregates around dolomite. The dolomite grains may be larger with calcite veins, or small grains with ternary junction grain boundaries. Both silicate and calcareous sub-domains contain apatite, zircon, rutile, sphene, pyrite, and monazite. The low temperature calcite has orange CL, while dolomite is red. Dolomite grains are compositionally zoned with Mg-rich cores and more calcic rims, which have brighter orange luminescence. The calcite veins are identified by their strong, contrasting CL response compared to host dolomite.

High temperature samples are coarser grained, have significantly fewer accessory minerals, and are characterized by silicate-mineral veins and inter-growths. Grain boundaries between calcite and dolomite are straight, except near veins of silicate minerals where calcite occurs as very fine-grained aggregates. Silicate minerals inter-grown with calcite have curved grain boundaries and no preferred orientation. Calcite and dolomite grains have orange and red CL respectively, but both minerals show a brightening of CL response at their grain boundaries, which weakly correlate with trace element abundances.

It is proposed that CL zoning in dolomite and calcite represent recrystallization textures that grew during emplacement of the igneous complex, and their increased CL response reflects the accommodation of changing abundances of trace elements, some of which may have been released into the bulk-rock system upon the breakdown of accessory minerals, which become increasingly rarer at higher temperatures.