*The outcrop of the Quaternary Blackwater Draw Formation in the vicinity of Slaton, TX*

# 12th Annual Department of Geosciences Research Day Abstracts Program

9th May 2018, 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 2018**
**9th May 2018**

Welcome to the 12th Annual Department of Geosciences Research Day!

The program this year presents 27 abstracts from graduate and undergraduate researchers covering a wide variety of topics highlighting ongoing research within the Department of Geosciences. Exactly 20 abstracts are first authored by geoscience undergraduates. This is about 30% less compared to last year's number of submissions, which is understandable, taking into account that undergraduate research became an elective course starting this year. And yet, the volume and quality of the abstracts authored by our undergraduates testify about their motivation and genuine interest in scientific research.

This year we will also have a team of four boys accompanied by their teachers from the Southcrest Christian School in Lubbock. This team advanced to nationals in the STEM competition. We welcome them to get some practice presenting their work before they go compete further.

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 three winning posters. Starting in 2014, the Society created a plaque for all top undergraduate posters. The plaque is presented in the 2nd floor display case. Please stop by to note the past winners.

Lastly, I would like to thank all of the presenters and their supervisors 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!

Branimir Segvic

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

*Indicates undergraduate researcher

## Interpretation of Changes in the Water-Level Altitudes for Castro County, Texas to Determine the General Water Depletion Rate between 2006–2016

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The Ogallala Aquifer is an unconfined aquifer and is the single most important source of water in the High Plains region of northwest Texas. In many places, the aquifer provides nearly all the water for residential, industrial, and agricultural (irrigation) use. An assessment of water level changes between 2006 and 2016 was made. For 2006, Castro County had a total of 158 wells available for this study, and 108 wells were available for 2016. The differences between the saturated thicknesses of the wells from the years 2006–2016 (ten years) were computed to interpret the changes in water levels of the Ogallala aquifer. In general, there has been an overall decrease (a county-wide average of approximately 22 feet [ft]). Declines in water levels during the period 2006–2016 in the amount of water in the Castro County has not been even all throughout the county. To clarify, some areas appear to have lost much more water than others, and some areas appear to have water level increases over the ten years. The water levels within the wells fluctuate for the period of 2006–2016 as most wells show a decrease water level. The few wells with increases do not change the conclusion that in general water depletion is occurring in Castro County.

## The migration of the shelf margin during the Pennsylvanian through middle Permian: Delaware Basin in Culberson, TX

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The Delaware Basin's southwest shelf, termed the Diablo Platform, runs through the middle of the study area in Culberson County. Chronostratigraphic surfaces that represent the end of the Atokan, Morrowan, Lower Strawn, Wolfcampian, Leonardian, and Guadalupian, were created with fusulinind biostratigraphy to analyze the migration patterns of the shelf margin. Shelf-edge locations were estimated on each chronostratigraphic surface by a downward inflection from shallow dipping to more steeply dipping. Migration of the position of the shelf edge in space allows for temporal patterns and rates of migration to be assessed. Through this analysis, two major patterns stood out. The first is along the northern half of the shelf; a reoccurring pattern of localized progradation is first visible in the Atokan and carries through to the Lower Strawn and Wolfcampian. The second is the unexpectedly slow rate of basinward migration during the Wolfcampian.

## Clay minerals as Quaternary climate change indicators in the Southern High Plains, West Texas

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The Southern High Plains in west Texas and eastern New Mexico forms a large plateau that was shaped during the last 2 Ma as the Pecos River incised to the west. Since that incision, the region has been mantled by eolian, both suspended and as sand sheets. Eolian sedimentation was cyclic, such that intervals of aggradation as loess or sand are followed by periods of landscape stability. Loess tops preserve paleosol, thus each cycle is a loess-paleosol couplet. Clay mineral composition of soil largely depends on the climatic conditions existing on land at successive periods of the geological history. The paleosols therefore comprise reliable indicators of paleo-climate.

In this work, we performed a fine-scale mineralogical investigation of a 5-m thick profile punctuated by at least three paleosols within the Pleistocene Blackwater Draw Formation exposed near Slaton, Texas. Our data indicate a subtle clay-mineral transformation indicative of changing climatic conditions. XRD mineralogy and SEM-EDS investigation both demonstrated three distinct clay-rich paragenesis. First, the bottom of the section exhibits smectite as a major clay phase with minor kaolinite and illite. Upwards, smectite loses its crystallinity, and is represented by several illite-smectite intermediates (second paragenesis) whilst the remaining clay assemblage is static. Finally, the very top of the section exhibits a complete disappearance of smectite and prevalence of detrital illite and kaolinite. Given a maximum age (1.4 to 2.0 Ma) for the Blackwater Draw Formation, this evolutionary trend of clay

minerals fits the progressive cooling in North America with a last glacial maximum set at ~20 ka.

## Comparing observations and simulations of the streamwise vorticity current in a tornadic supercell storm

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Baroclinic zones have long been known to exist and play an important role in the vorticity budget of a supercell, particularly at low levels. While the periphery of the rear flank downdraft (RFD) has been shown to be an important source of baroclinic vorticity generation, the forward flank has not been investigated as thoroughly. Studies have shown that convergence zones may exist within the forward flank in supercells. These convergence zones exist along density gradients, where the storm relative flow is along the boundaries toward the updraft. Therefore, baroclinically generated streamwise vorticity can accumulate and feed into the updraft. Recent high-resolution simulations of supercells Orf et al. [1] have produced intense realizations of this vorticity in the lowest 250 m AGL within the forward flank, a feature identified as the streamwise vorticity current (SVC).

During the Rivers of Vorticity in Supercells (RiVorS) project in the spring of 2017, a suite of instrumentation was used to observe these baroclinic zones and vorticity rivers in supercells. One of the Texas Tech Ka band radars was used to capture RHIs from the RFD through the forward flank of a supercell at high resolution (0.33 degree beamwidth). Five datasets were gathered during this project including one tornadic case.

On June 12, 2017 a tornadic supercell was observed northeast of Cheyenne, Wyoming. A sector of RHIs was gathered continuously for 30 minutes from tornadogenesis through tornado decay on this storm. Prior to storm initiation, a mobile observed sounding was launched from NSSL's P1 mobile mesonet to sample the pre-convective environment. Using this observed sounding, a supercell was simulated using CM1. Simulated RHIs in the simulated storm are compared to the observed RHIs showing areas of broad horizontal vorticity near the surface. The simulated storm is also visualized with VAPOR to show the SVC present.

[1] Orf et al. (2017) *Bull. Am. Meteorol. Soc.*, **98**, 45–68

## Conodonts of the Lower Mississippian Chappel Limestone, Bend Arch, Shackelford County, Texas

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Conodont samples discussed in this report are from the poorly understood late Kinderhookian-Osagean succession (pre-Chappel-Chappel) on the Bend Arch, North Texas. All Conodonts were recovered from the Hilltex River Ranch 364#1, Shackelford County, Texas and is the most complete section of Mississippian strata located in Texas. The lower Chappel Limestone is a red crinoidal lithoclast wackestone-mudstone at the base of the Chappel Limestone and a light grey crinoidal packstone-grainstone at the top of the study area.

Conodont faunas were investigated to see if the Chappel limestone in the Llano area of central Texas correlates with the Chappel Limestone located in north Texas. Conodont genera present in the core are *Siphonodella*, *Bactrognathus*, *Staurognathus*, *Polygnathus*, *Pseudopolygnathus*, *Protognathodus*, and *Gnathodus*. Zones present in the pre-Chappel and Chappel Limestone range from Zones 1F to 4L in the Mississippi Valley zonation scheme of *Lane and Brenckle (2005*) [1], which are late Kinderhookian to middle Osagean in age. However, Zone 2 conodonts are missing from the section and Zone 3A is very thin, suggesting the presence of an unconformity at 4808 to 4809 feet. Strata below this break are older than the type Chappel and form a "Pre-Chappel" unit not found in the Llano region. The strata above the unconformity is the same age as the type Chappel found in the Llano area of central Texas as described by *Ruppel and Kane (2014)[2]*.

[1] Lane, H.R., and Brenckle, P.L. (2005) International Union of Geological Sciences Subcommittee on Carboniferous Stratigraphy Guidebook for Field Conference, St. Louis, Missouri, September 8-13, 2001, ISGS Guidebook 34, p. 80-87.

[2] Ruppel, S.C., and Kane (2014) The Mississippian Barnett Formation: A Source-Rock, Seal, and Reservoir Produced by Early Carboniferous Flooding of The Texas Craton: BEG. Jackson School of Geosciences, The University of Texas at Austin. Austin, TX. p.1-13.

## Evaluation of Wolfcamp Prospect Delaware Basin

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The zone of interest (Wolfcamp 1) is lower Permian in age located in SE New Mexico, Delaware Basin. The Delaware Basin makes up approximately 10,000 square miles. The formation is characterized by shallow water carbonates interbedded with fine grain organic and clay rich siliciclastic mud.

A full well-log suite including geochemical data was utilized to determine whether to complete the zone of interest. Our team was provided NMR log data to import into Techlog by Schlumberger for analysis. Then the OOIP was estimated and a conservative OOIP was corrected using a permeability cutoff at 1 μD. The potential zone is seen at 9975 ft – 10150 ft.

With given information, Young's modulus, Poisson's Ratio and shear modulus were calculated. Interestingly, the data shows very favorable high values for the upper section. Such trend implies the fracture tendency to be upward. In other words, our landing point is suggested to be in lower depth so the fracture could travel upward. The average formation pressure gradient was calculated using bulk density and it found to be $1.107\frac{Psi}{ft}$. Pore pressure gradient was assumed to be $0.433\frac{Psi}{ft}$. Accordingly, the effective minimum horizontal stress was then calculated for each depth. 10,135 ft was chosen to be the best landing point where all geomechanical and geophysical properties are favorable. Based on our petrophysical calculations, our team calculated a total OOIP of 87,500bbl/acre. We broke up this section into four 160-acre spacing well locations. According to SPEE Monograph III, "If the EUR statistical distribution for each area is comparable, then each area is an extension of the resource play, and areas bound by the concentric circles should be Proved reserves." Knowing that this well is in a proved area, based off statistical analysis, we can strongly conclude that one of these four wells will be a 6% RF. In our analysis we assumed a 100% WI and 75% NRI. After production taxes, ad valorem taxes, drilling/completion cost, and monthly well cost, we have the potential of profiting $16 MM/yr/well in cash flow.

## Petrophysical Analysis of the Wolfcampian Shale

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The Delaware Basin, element within the Permian Basin Province, was created during the formation of Pangea in the late Paleozoic. The suturing of Gondwana to Laurentia along the Ouachita-Marathon belt resulted in uplift and down warping in the area of west Texas and New Mexico. The precursor to the Delaware Basin formed during the Late Mississippian from the Tobosa sag through "…densification and compaction by underlying deep crustal or mantle layers," essentially lithospheric cooling and associated isostatic adjustment (Adams, 1965). The formation in question is the Wolfcamp shale, broken into A and B counterparts, that formed in the Permian.

We were provided a geochemical analysis, along with a full log-suite to evaluate production potential in well 5399-18. Microsoft Excel and Techlog provided by Schlumberger were programs used for calculations. These calculations included total porosity, effective porosity, total organic carbon, clay bound water, geomechanics, etc. The OOIP was calculated using a conservative permeability cutoff of 1μD. A net pay zone was found at 9,975 to 10,175 feet in the upper A constituent of the Wolfcamp. For the total 640 acres, the OOIP was calculated at 12.9 MMSTB. With minimum horizontal stress and brittleness coefficient parameters, the well penetration location was determined at 10,075 feet. The economic analysis was estimated with a recovery factor of 3% to 6% for 4 wells with fracture half-length of 200, 300 and 400 feet. The ultimate decision is to complete the well based on final economic results.

[1] Adams, J. (1965) *AAPG Bulletin* **49**, 2140-2148.

## Using Mobile Doppler Radar Observations of Gust Fronts to Infer Buoyancy Deficits within Thunderstorm Outflow

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It has been shown that non-tornadic and weakly tornadic supercells are associated with RFDs containing large deficits in equivalent and density potential temperature, while strongly tornadic supercells produce RFDs with much weaker deficits. This study proposes that the thermodynamics of an RFD can be inferred from the propagation speed and vertical structure of the RFGF. In several ad-hoc field campaigns, the Texas Tech University Atmospheric Science Group used Ka-band mobile radars to document the vertical structure of a number of severe thunderstorm outflow events, both from supercells and upscale modes. In each case, the thermodynamic state of the inflow and outflow air is sampled and ambient shear is estimated using velocity azimuth displays and North American Regional Reanalysis data. These values are used as a baseline to initialize two-dimensional CM1 cold pool simulations to quantify the similarities between observational and theoretical outflow structure and speed.

Two-dimensional model results reveal that, in the same sheared flow, the edge of a strong cold pool is less inclined than that of a weaker cold pool. Also, outflow in weak ambient shear has a steeper slope than the same outflow in stronger ambient shear. A nonlinear multivariate regression is performed on the free-slip model data to quantify cold pool slope given ambient shear, shear depth, and potential temperature deficit. The regression equation is applied each of the observed cases and it is apparent that the model over-predicts the cold pool slope for all cases.

## Compostions of augite and amphibole from lampyrophre, Sacramento mountains, Otero county, New Mexico

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Tertiary lamprophyres (camptonites) found in the dikes and sills of the Sacramento Mountains, New Mexico, contain phenocrysts of amphibole and augite with a groundmass consisting of plagioclase, chlorite, magnetite, apatite, calcite, and epidote. The amphibole and augite phenocrysts were analyzed by electron microprobe and laser ablation ICP-MS for major oxides and rare earth elements compositions specifically to determine core to rim zoning. Zoning of rare earth elements and major oxides in both augite and amphibole suggests that magma evolution involved fractional crystallization accompanied by magma mixing.

## 1-D modeling of the crust beneath Nacadoches, Texas to test a new WID based inversion method

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RFs time series are processed from seismic data to emphasize P-to-S converted phase (Pds, where d is the depth where the P was converted to S) from the Moho and crust layers. The problem with this technique is that reverberations or multiples (PPds and PSds phases) can be misinterpreted as and interfere with Pds phases. Wavefield Iterative Deconvolution (WID) separates the multiples from the Pds phases to produce separate RFs for the Pds, PPds and PSds phases. Data from the NATX seismic station was processed using the WID as a sample data set to test a new WID based inversion method. This technique used a weighted inversion method with restrictions that guide acceptable models to geologically reasonable model space. The inversion was repeated hundreds of times using a simplex method. The simplex method can get stuck in local minimums and therefore allows us to explore the sensitivity of the inversion strategy to different possible models. Future efforts will use better methods such as genetic algorithms. For most models, the P-wave structure fell within reasonable space and gave geologically plausible models for the area. The S-wave models were much more variable in character and did not appear to resemble plausible models. They had several large low velocity layers that were not plausible given that they were not present on the P-wave models. We believe we were too restrictive in how we allowed the inversion to explore model space, which resulted in the S-wave models to plateau in unreasonable space. The weighted method put more

weight on the Pds waves than PPds or PSds phases. Both Pds and PPds waves are necessary to calculate an accurate $V_p/V_s$ ratio so this may have hindered the accuracy of the inversion. In further research, we recommend using the technique with fewer restrictions on allowable model space and weight the Pds and PPds phases equally. In the end we found the WID inversion resulted in more plausible models. The 10 layer allowed a gradational Moho that seemed to fit the data better. The major features were a sediment basement contact between 5 km and a Moho at about 30 km. The mantle had a velocity of ~7.5 which indicates a transitional mantle left over from the rifting of the Gulf of Mexico.

## Spatial Delineation of a Prograde Metamorphic Gradient, and Quantitative Analysis of Localized Shear Zones within Successive Micaceous Quartzites in the Southern Wet Mountains, CO.

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New mapping has identified a previously unrecognized mylonitic shear zone and revised a sequence of prograde metamorphic isograds within the Blue Ridge area of the Wet Mountains. The lithologies in this area represent a metasedimentary pendant bound by granitic plutons to the north-west and south-east. The metasedimentary lithologies are composed of quartzite which ranges from pure (NW) to biotite-dirty (SE), meta-conglomerate, and schist of various metamorphic grade. This metasedimentary pendant is intruded upon by multiple phases of granitoid and pegmatite magmatism as well. The metasedimentary units experienced intense shortening from the north-west and south-east, leaving the units displaying a sequence of asymmetric isoclinal folds. The metamorphic packages of sedimentary protolith on average trends NNE and are oriented near vertical. Traversing from NNE to SSW, rock structures and dip directions are not uniform. The succession of rocks are tight to isoclinally folded, cut by localized shear zones, and intruded by two igneous units. Combining the new mapping and structural analysis and previous work, two models may be evaluated for the tectonic evolution of the field area. Past research records multiple shear zones surrounding the area, but there is debate over their causation. The shear zone discussed in this research is unmapped by past researchers and presents new data to analyze in effort to determine if the newly mapped zone is a result of the same processes that have been previously proposed. There are two possible kinematic explanations for the shear zones. Two hypotheses may explain the relationship between the newly recognized shear zones and prograde metamorphic isograds. In hypothesis 1, deformation of this pendant formed through regional tectonics leaving isoclinal folds and shear zones. In hypothesis 2, metamorphism is induced through contact of igneous bodies intruding the area. Both hypotheses are perfectly plausible, and the cause for deformation can plausibly be a mixture of both mechanisms. In a roughly mile long traverse from NNE to SSW, four metamorphic zones separated by mappable isograds were mapped; regional muscovite followed by biotite-in, garnet-in, and garnet + sillimanite-in. These isograds are broadly parallel with the structural grain of the map area. Based on this suit of index minerals, the temperature and pressure zone these metamorphic rocks were formed in is roughly 380 MPa and 445-550 ˚C respectively.

[1] Sullivan, J.C. Spatial Delineation of a Prograde Metamorphic Gradient, and Quantitative Analysis of Localized Shear Zones within Successive Micaceous Quartzites in the Southern Wet Mountains, CO., Undergraduate Research Thesis, Texas Tech University.

## Late Paleozoic Chronostratigraphic Evolution of the Southern Delaware Basin in Jeff Davis and Presidio counties, Texas

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The Permian Basin is a hydrocarbon bearing region located in Southeastern New Mexico and west Texas. The Delaware Basin is the western half of the Permian Basin and formed as a result of subsidence during the late Paleozoic formation of Pangea. The strata filling the Delaware Basin are the accumulation of clastic and carbonate sediments as the shelf prograded. The southwest portion of the Delaware Basin is not well studied and as a result most subsurface maps are schematic. The focus of this project is to better understand the subsurface through the use of structure maps produced from biostratigraphic zone tops in wells drilled in Jeff Davis and Presidio Counties.

The Atokan chronostratigraphic surface shows that a steeply dipping ramp dipping south-east existed and remained relatively unchanged through the Lower Strawn. During the Wolfcampian the shelf regressed forming a gradually sloping shelf margin in contrast to most of the Delaware basin which filled through progradation. The Leonardian shows a slight deepening of said shelf margin as further evolution of the area.

## Smectite stability in alternating mudstone-sandstone facies from the Pennsylvanian Hoxbar Group (Anadarko Basin, Oklahoma)

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One of the most prolific sedimentary basins in North America is the Anadarko Basin located in the central part of the United States (Oklahoma and north Texas). It is also the deepest structural and sedimentary basin in the cratonic interior of the United States, containing approximately 12 km of Cambrian through Permian sediment in its deepest portion, with a total thickness of the Pennsylvanian strata reaching 3-4 km. The studied Pennsylvanian shale and sandstone belong to the Hoxbar Group, which is a thick sedimentary unit made of multiple shaley horizons that are interbedded with sands. Two cores were sampled from a depth of about 3 km.

The amount of detrital clays in sandstones is usually modest, owing to hydrodynamic sorting and other depositional processes, whilst in mudstones clay minerals are abundant and are mostly inherited directly from the original sediment. Illite-smectite from the prograde diagenetic series is common in both lithologies and subtle changes in its crystal chemistry and component makeup may be considered as proxies of the continuously changing diagenetic conditions. If one assumes the uniform source of detrital clays, than the smectite evolution in such alternating series may result with (1) a similar specific composition of I-S in sandstones and adjacent mudstones, (2) lower smectite in I-S in sandstones compared to I-S of alternating mudstones, and (3) higher smectite in I-S in sandstones compared to I-S of alternating mudstones. The reasons for such dynamics are multiple and are generally related either to the differences in thermal stability of authigenic and detrital smectite or to enhanced flow rates in sandstones that promote illitization of smectite.

This work examines the depositional environment of the Hoxbar Group along with diagenetic aspects of alternating shales and sandstones. The latter presumably exercised a major influence on the evolution of smectitic clay assemblages and, given an increasing significance of Pennsylvanian strata of the Anadarko basin in the exploration of hydrocarbons, a detailed knowledge of clay mineralogy of shales and associated sandstones becomes critical for predicting the distribution of high-quality reservoirs and for the exploration of their forming mechanisms. Our preliminary data shows that the average clay mineral content in sandstone of the Hoxbar Group is about 6% compared to 35% of clays in mudstone. In the latter, several generations of illite-smectite, including rectorite, dominate the clay fraction. On the other hand, clays in sandstone are illite-rich I-S with only minor rectorite component and kaolinite. This clearly shows a facies control on clay speciation but it also points to the effect of higher permeability of sandstone or, alternatively, the impact of the circulation of hot fluids facilitating higher diagenetic rates characteristic of an open diagenetic system. Such smectite dynamics in neighboring sandstone and mudstone layers may also suggest different rates of authigenesis of smectite in analyzed rock types, which is subject to further investigation.

## Trace Element Abundances in Apatite and Biotite from Kentallenite of the Balachulish Igneous Complex

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The Kentallenites of the Ballachulish Igneous Complex are part of the Appinite Suite that predates the main phase of magmatism. The Kentallenites are characterized by an assemblage of olivine + clinopyroxene + biotite + orthoclase + plagioclase with accessory apatite. Olivines and clinopyroxenes are found as phenocrysts in a matrix of biotite, plagioclase, and orthoclase. Optical and electron- microscopy aided petrography was applied to discern probable sequences of mineral crystallization, which were used to interpret trace element partitioning.

Back-scattered electron and cathodoluminescence imaging of biotite and apatite grains show that the phases are

compositionally homogenous with no evidence of internal zoning textures that may be attributed to growth or alteration.

Apatite REE patterns have negative slopes (LaN/LuN=13.24 and 20.49) and all spot analyses have positive Ce-anomalies (Ce/Ce*=1.07-1.21) and negative Eu-anomalies (Eu/Eu=0.44-0.67), suggesting oxidizing conditons in the magma. Apatites with multiple analyses are largely homogenous and show almost no variation in REE patterns.

Trace element analyses of biotites show that the middle to heavy LREEs are below detection limits. Chondrite normalized LREE patterns, including La, Ce, and Eu, have a negative slope. Biotites show trace element zonation in V, Ti, Sr, Zr, Ba, Eu, and Li but there is no evidence that the distribution is systematic. Preliminary interpretation of trace element distributions suggests that apatite primarily controls the distribution of light to middle REEs.

## Evaluating Element Transport in the Thermal Aureole of Ballachulish Igneous Complex, Scotland

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The 427 ± 1 Ma Ballachulish Igneous Complex and associated thermal aureole is a plutonic-metamorphic system that exposes a variety of metasedimentary compositions. Metasedimentary units are orientated NE-SW sub-perpendicular to the contact with the igneous rocks enabling multiple lithologies to be studied down temperature gradients or at equivalent temperatures. The locality is an ideal location to evaluate element behavior during metamorphism.

Regional-grade metasediments were thermally metamorphosed during the intrusion of the igneous complex, and five zones may be identified based on mineral reactions and assemblages.

Rock samples from five transects were crushed and powdered, and after acquisition of loss-on-ignition data, were mixed with flux and fused to a glass disc for major element analysis by X-Ray fluorescence spectrometry, followed with trace element analysis by laser ablation-inductively coupled plasma-mass spectrometry data. Plots of major element abundance, chondrite normalized rare earth element abundances, and element abundances normalized to regionally metamorphosed compositions as a function of temperature and distance from intrusion were prepared.

The chondrite normalized rare earth element abundance plots for all five transects show a negative Europium anomaly. Another pattern is that trace elements are more abundant at higher temperatures and less abundant at lower temperatures throughout the contact-perpendicular transect in the Creran Succession. Otherwise, no other systematic patterns were observed in the transects as a function of temperature in the aureole.

## Evolution of the Marathon Foreland Basin in Terrell County, Texas

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Terrell County is located in the Permian Basin of West Texas. To assess a time-equivalent evolution of the region, chronostratigraphic data was constructed with the help of fusulinid biozone tops. Surfaces constructed from Lower Strawn through Leonardian Series allow visual representation of the evolution of the Marathon foreland. The surfaces incorporate the data of 40 wells that were interpreted from 1927 through 1975 by R.V. Hollingsworth. The results showed a steady migration on the Lower Strawn through Leonardian surfaces of a structural high from southwest towards northeast potentially caused by loading from the Marathon thrust belt.

## Petrology of Comanche Peak Limestone (Cretaceous) near Fluvanna, TX

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The Comanche Peak Limestone differs significantly between outcrops in the Fluvanna area and the Sweetwater area. Limestones at Fluvanna are nodular, argillaceous, sparse biomicrites with wackestone to packstone textures, thin marlstone interbeds, and extensive bioturbation. Skeletal grains include mostly thin ostreid bivalve (‘oyster’) shells, gastropods, and echinoids. These features indicate that limestones in the Fluvanna area were deposited in an open shallow marine, subtidal lagoon environment with low-wave energy. In contrast, limestones in the Sweetwater area are cross-bedded, packed biosparites with packstone to grainstone

textures, and little or no bioturbation. Skeletal grains include mostly calcareous algae and foraminifera (mililoids) with nonskeletal grains consisting of intraclasts and peloids.

These features indicate that the Sweetwater limestones were deposited in a shallow marine, beach or inter-tidal environment, with moderate to high-wave energy.

## Using Garnet Trace Element Geochemistry to Determine Magmatic versus Metamorphic Histories in the Mora Pegmatite Suite, Mora County, New Mexico

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Proterozoic rocks in Mora, New Mexico, in the Sangre De Cristo Mountains are intruded by a poorly described suite of pegmatite bodies. Pegmatites in the area occur as numerous, meter wide bodies that generally follow layering in metamorphic rocks. Smaller boudined bodies range in size from a few centimeters to meters wide, as well as discrete lenses of only a few centimeters wide. Pegmatites are classified as simple, muscovite class (London, 2008) and contain plagioclase + quartz + alkali-feldspars + garnet ± muscovite ± biotite with accessory apatite, monazite, and zircon. This project uses garnet trace element geochemistry to identify and track emplacement versus metamorphic histories of some pegmatites.

Electron-microscopy based BSE and EDS, coupled with LA-ICP-MS analysis of trace elements were used to characterize the compositional and textural properties of garnet in each studied sample.

Garnets were assigned to one of two populations: 1) large, subhedral to anhedral, heavily fractured grains; and 2) smaller, euhedral, unfractured grains. The fractured grains have chlorite + Fe-oxides along many fractures. Garnets mostly are unzoned in BSE images with one exception.

All analyzed garnets show a relative enrichment of Fe and Mn in cores compared to rims, making them normally zoned with respect to spessertine and almandine content. Chondrite-normalized REE values show that the garnets are HREE enrichment compared to LREE and all garnets have negative Eu-anomalies. Garnets from different pegmatite samples, texturally, show variations in HREE abundances. Based on trace element geochemistry there are three compositional populations: 1) garnets with positive HREE slopes and abundances less than 100,000 chondrite, 2) garnets with positive HREE slopes and abundances greater than 100,000 chondrite, and 3) garnets with flat to slightly negative HREE slopes that have abundances less than 100,000 chondrite. Each of these populations is found in a unique locality suggesting that there are multiple generations of pegmatite that had distinct magma sources and origins.

## Geothermobarometry of an Orthogneissic Monzonite

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Predicting the pressure (P) and temperature (T) of metamorphism is an important component of re-constructing geologic histories. Increasingly, P and T are modeling using the Gibbs energy minimization approach that uses whole-rock compositional data and a range of internally consistent thermodynamic databases to calculate isochemical phase diagrams. Recently, a number of databases and amendments have been released. Amendments are presented as improvements, but, it was noted that different modeling strategies result in different outcomes for equivalent P-T-X conditions (*Pattison, pers comm*), which contributes to conflicting results and uncertainty over interpretation especially in complex rocks.

Models using different databases are calculated for an orthogniessic monzonite with partial melt textures from the Raftsund Batholith, Norway. Whole-rock composition for the studied sample were collected by crushing, powdering and fusing the sample to make glass discs for major element analysis by XRF. Thermodynamic modeling used Theriak-DOMINO (Capitani & Petrakakis, 2010) and internally consistent thermodynamic databases by Berman (1988) and Holland and Powell (1998).

The orthogneiss is an equigranular microcline-bearing garnet-biotite-plagioclase-amphibole gneiss. The garnet are euhedral with occasional embayments filled by quartz + microcline with triple-point crystallization textures. Compositional analysis shows that the garnet have bell-shape Mn and Mg profiles, constant Fe content and reverse zoning in Ca. Thermodynamic models calculated using the JUN92 database (Berman 1988), were inconclusive and the observed assemblage was not calculated. The Holland and Powell

database calculated an incongruent melting reaction that produces garnet. Comparison of garnet compositions with calculated isopleths suggests that garnet cores may have grown at 9.5 kbars 725 °C. A clockwise decompression and cooling path is inferred because the melt + garnet-out reaction, followed by crystallization of melt in the absence of strain occurs at lower P. Manganese was resorbed into garnet-rims during garnet + melt reactions; garnet rim compositions were not modeled because the garnet + melt reaction did not go to completion and garnet is preserved as a metastable phase.

## Lightning and radar observations for upward lightning-producing thunderstorm in Oklahoma

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Upward Lightning is a cloud-to-ground lightning that is initiated at tall structures and propagates towards the cloud. It is not the most common type of CG lightning flash although it can cause serious material damage to towers, tall buildings, and windmills. It has been reported to be initiated by previous electric activity during the decaying stages of thunderstorms, and associated with stratiform precipitation. The purpose of this study is to examine the thunderstorm structure in terms of microphysical and electrical characteristics that produce upward lightning flashes. We use observations of a thunderstorm that produced 39 upward lightning flashes in an region within twenty tall towers (100 – 500 m) in Oklahoma City, Oklahoma, USA in two hours. These observations are from operational KTLX Weather Surveillance Radar-1988 Doppler (WSR-88D) radar and from ground-based three-dimensional Lightning Location Systems by the Oklahoma Lightning Mapping Array and two-dimensional by National Lightning Detection Network and satellite-based Geostationary Lightning Mapper. They demonstrate key parameters of cloud vertical structure that produce this type of lightning flash. The results of this research are important to increase the understanding of the phenomenon, the storm evolution and the predictability of upward lightning flashes.

## The Effect of Perturbation Pressure on Thunderstorms

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The poster presents the impact of the vertical shear on the propagation, strength and maintained of updrafts of (supercell) storms.

The Buoyancy force, which is due mainly to latent heat, is the main source of the updraft strength for thunderstorms. In the Midlatitudes the interaction of the updraft with high wind shear in the mid and upper troposphere leads not only to more organized storms (separation of up- and downdraft). This interaction also produces a perturbation pressure field around and in the updraft that leads to additional vertical accelerations. Especially in cases of environments with high shear and low buoyancy force it is possible that the updraft strength is considerable higher than expected.

To show the effect of vertical shear and perturbation pressure on storm updrafts, three idealized storm simulations with the Bryan Cloud Model 1 (CM1) will be discussed. The first simulation is realized in an environment with only increasing wind speed with high (straight hodograph) and in the second simulation the wind also changes direction with height. To show how the storm evolution proceeds without wind shear a third simulation is present.

Additionally it will be shown how the different kinds of perturbation pressure sources effect storm splitting, propagation.

## Interpretation of shallow seismic reflection beneath a Playa Lake

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The purpose of this research is to image the subsurface of a playa lake located 10 miles north of Lubbock Texas on the Texas High Plains. This is part of a larger project to image playa lakes to better understand the infiltration through the playas. The data was collected by taking a seismic thumper and thumping the ground to create seismic waves. The waves

were recorded by RT125a data loggers (Texans) hooked to 4.5 Hz geophones. The recordings were processed to produce images of CMP gathers. We picked the arrival times vs offset for a shallow reflection. We determined that the reflector was between 10 to 12 meters in depth with an average velocity above the layer of 70-100 (m/s).

## Investigation of the Lateral Variations in Soil Texture in a Playa Lake Northwest of Lubbock, TX

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This abstract applies to two related posters by the first two authors above. They are analyzing the same set of soil samples. One (Billy Gillis-Harry) will focus on an interpretation of these results as a function of Depth while the other (Garza) will focus on an interpretation as a function of position. The soil samples were taken from a playa lake northwest of Lubbock. It is one of two very closely spaced playas (only a few meters apart). Our playa of interest tends to dry quickly while the other holds water for a longer period of time. The sediment samples were taken from 8 holes at 10 meter spacing starting at the inter playa annulus and ending within the playa. Samples were taken from each hole at depths of 0m, 0.5m, 1m, 1.5m and 2m. Grain size analysis was preformed using an LS 13 320 Laser Diffraction Particle Size Analyzer. In general we found there to be a large amount of sand in all the holes. This may be the result of insufficient disaggregation before grain size analysis. But if we assume the results are meaningful, we may conclude that our playa dries quicker than the other playa as a result of the sand content. The three holes nearest the interplaya annulus all had clay content of more than 50%. Hole 6 also had a high then 50% sand content. Hole 6 may be in a mudcrack (the playa was wet so these cracks were not visible).

## Electrical Investigation of the Llama Playa's in the High Plains of Texas

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In the Spring of 2017, our undergraduate research team was tasked with the Geophysical investigations of the Llama Playas located 12 miles northwest of Texas Tech University. The research team collected resistivity data transecting two small playa lakes then ending about 20 meters outside the annulus. Our main goal was to investigate how infiltration occurs in the playa lake by repeating the imaging before and after rainstorms and infiltration test with a soaker hose. The team also placed two wooden box infiltrometers that we would fill with water to induce saturation in the playa. One was on the annulus and the other was in the middle of the playa. Resistivity data was collected using a Dipole-Diploe array. The ground was charged with twenty-four nine volt batteries connected in series with a large enough resistor to regulate a steady flow of current. We inverted the data to produce a 2-D model of the resistivity of the ground beneath the playa using the res2Dinv program. The conductivity of the clay bed of the two playa lakes are similar and appeared to be flat at about 3.75 meters deep. After flooding we see a plume of water (low resistivity area) beneath the interplaya annulus. There was also a plume of water in the east playa beneath the location of the soaker hose and near the annulus. There is a standing dug out tank in the western playa that does not appear to have a plume beneath it. After a rain, we observed that the west playa retained water better than the eastern playa. The fact that there appeared to be infiltration associated with the western playa but not the eastern suggests that the sediment of the eastern playa is more permeable. See the soil sampling posters.

## Petrophysical Evaluation of the Delaware Wolfcamp Shale

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The Permian Basin is one of the most widely recognized oil and gas producing regions in the United States. It covers an area of approximately 75,000 square miles and encompasses 52 counties in southeastern New Mexico and western Texas. The Delaware Wolfcamp Shale in Permian Basin is a separate formation that lies beneath the Bone Spring, it is about 2,000 ft thick. This formation deposited as shallow water carbonates, inter-bedded fine-grain organic-rich

siliciclastic mud with organic-poor clay-rich mud. The Delaware Wolfcamp is largely a horizontal oil play with a median hydrocarbon mix similar to the Bone Spring at 60% crude, 20% wet gas and 20% dry gas.

Well 5399-18, which is closely related to Delaware Wolfcamp Shale, is assigned for analysis. Necessary calculations were conducted applying Microsoft Excel and Schlumberger Techlog 2015. Parameters were estimated, including: Kerogen Volume, Total Organic Carbon (TOC), Effective Porosity, KSDR (1 μD) Cutoff OOIP, Brittleness Coefficient and Minimum Horizontal Stress (σhmin), etc. The lateral landing point is recommended to be 10,112 ft based on a comprehensive evaluation including selected pay zone thickness (9970 – 10333 ft), hydrocarbon saturation, brittleness coefficient and σhmin. The estimated ultimate recovery (EUR) is 1004 MBO, and the volumetric original oil in place (OOIP) is 16.73 MMBO with the drainage area of 160 acres and the recovery factor of 6%. Economics was also evaluated, the recommendation of completing the well depends on the economic result.

## Apatite Chemistry and its Relationship to Magma Composition in the Tuolumne Intrusive Complex

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The Tuolumne Intrusive Complex in Yosemite National Park, California comprises a range of units, from oldest to youngest: Kuna Crest, equigranular Half Dome, porphyritic Half Dome, Cathedral Peak, and Johnson porphyry. Results presented here indicate that the chemistry of accessory apatite provide insight to the petrogenesis of these units and possible relationships with one another. Apatite was analyzed by cathodoluminescence CL imaging, electron microprobe, and laser ablation ICP-MS. From the outermost unit to the innermost unit, the REE patterns change from a chondrite normalized smooth pattern that is relatively steep in slope to a shallow slope that depicts negative anomalies. Distinct compositional groups can also be recognized on the basis of the element strontium (Sr) versus the elements yttrium (Y) and vanadium (V). These results show that apatite is host to rare earth elements throughout the Tuolumne Intrusive Complex and demonstrate that apatite can be used as a tracer mineral to predict the composition of the magma. This in turn will allow direct access to the composition and petrogenesis of the pluton magmas.

## Determining Protein Levels in Insects: Feeding a Growing World

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Is there a suitable insect whose protein levels are high enough and similar enough to meat to feed a growing world? Could insects provide a sustainable and environmentally responsible amount of protein while lowering greenhouse gas emissions? Potential food sources were tested for protein percentages using biuret solution for qualitative measures. Termites, mealworms, crickets, grasshoppers, and silkworms were ground, added to water, and dissolved before using a color comparison chart to see the relative amounts of protein in each kind. As a control, albumin was used to represent 100% protein and distilled water was used to show 0% protein. In these tests, grasshoppers had the highest amount of protein and silkworms had the least amount of protein.

For quantitative data, a spectrophotometer was used to measure exact amounts of protein. Insects were weighed on a digital scale, ground and dissolved in water, then placed in cuvettes within the spectrophotometer. The instrument was calibrated using water for 0 protein and albumin for pure protein. Results showed the grasshoppers had the highest levels of protein.

Cricket flour was used to make a homemade Cricketeer Protein Cookie. Testing showed it to be high in protein. As a complete meal to replace traditional meat, insects can be used and would be more efficiently transported overseas where they are most needed. Hunger can be fought by using non-traditional methods of feeding the world, starting with crickets.