TEXAS TECH UNIVERSITY
College *of* Arts & Sciences

Department of Geosciences

Department of Geosciences
Texas Tech University
Research Day 2011

Welcome everyone, to the Department of Geosciences 2011 Research Day.

All contributions to the event are greatly valued and it is wonderful to see the full spectrum of research activities in the Department on display. Nevertheless, the principle reason behind the event continues to be the celebration of research accomplishments by our graduating students. Their contributions will be shown in and around room 230 (the same place as the coffee and cookies) and their abstracts are marked in this volume by a †; please note we have at least a dozen undergraduates presenting!

Undergraduate research has taken on a new dimension and importance this year. University administrators have identified undergraduate research as an important plank in demonstrating the vertical integration of research into the TTU curriculum, and the benefits for undergraduate education and retention. The National Science Foundation, with the support of Congress, continues to develop and expand its opportunities for undergraduate research funding.

The Department is well placed to benefit from both internal and external opportunities designed to enhance and develop undergraduate research, and we have a strong base from which to promote ourselves as campus leaders in undergraduate research education.

I would like to thank the Geoscience Society who will once again support a BBQ lunch in Room 201 (Structure Lab) from 12:15 onwards.

Finally, thank you to everyone, presenters and viewers, for coming along to participate in the event. I hope that everyone enjoys the morning and is inspired for their upcoming summer of research.

Callum J Hetherington

CONSTRAINING THE ONSET OF CRETACEOUS PERALUMINOUS MAGMATISM IN THE RUBY MOUNTAINS, NEVADA

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The Ruby Mountain – East Humboldt Range (RM – EHR) in northeast Nevada exposes at least three generations of peraluminous granites that are Cretaceous or younger. On the basis of field relations, an equigranular banded gneiss is the proposed to be oldest, the equigranular granitic gneiss of Lee et al. (2003). Monazite from a single sample has been dated to 94 – 92 Ma. However, the complexity of the magmatic system and field relations and evidence for post-emplacement deformation, this is viewed as a minimum age. Samples have been prepared for petrography and zircon geochronology to better constrain the emplacement age and source of the rock.

The accessory mineral budget of all samples is dominated by monazite that is sub-hedral to rounded in shape and ranges in size from 100-200 µm and appears to be compositionally homogenous. Zircon is rarer and dominated by three morphologies: 1) a 200 µm long needle-like form with a length to width ratio of ~8:1 and prismatic terminations; ~150µm subhedral prismatically terminated zircon with length to wide ratios of 2:1; and, ~100µm gemmy rounded (soccer ball) grains. The first two populations commonly display oscillatory or sector zoned cores, surrounded by oscillatory zoned rims. The rounded population contains oscillatory zoned euhedral cores overgrown by rounded, oscillatory zoned, rims. Grains from all populations sometimes display a thin, <10 µm, outermost rim, which is particularly prevalent at prismatic terminations, of brighter cathodoluminescence; this is interpreted as a third stage of zircon growth.

Preliminary U-Pb dating of the oscillatory zoned rims indicate ages of 85, 88.5 and 90.5 Ma. This age somewhat compliments the existing monazite age, but the data shows a significant spread suggesting that the magmatic evolution, emplacement, and post-crystallization history of the lithology may be more complicated than originally proposed.

LOG ANALYSIS of an "OLD" E- LOG

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The "OLD" E – LOG with this example sandstone [4666' – 4678'] is a Lane Well ES [electrical survey] from the 1940's. The logging suite consists of the following:

Curve – 1 Natural Potential (SP)
Curve – 2 Shallow Penetration (Short Normal)
Curves – 3 and 4 Deep Penetration (Laterals)
Point Electrode (*Pt.*).

On the log header no Rmf (resistivity of the mud filtrate) was recorded only the resistivity of the mud was recorded (Rm). In order to do any quantitative log analysis two important pieces of information are required. First a value for Rmf must be obtained by the following equation (Rmf = 0.847*Rm^1.07). Second the electrode spacing (AO) of the two deep penetration curves (Curves – 3 and 4) must be obtained. AO electrode spacing was obtained by the distance to a reflection peak below a thin resistive bed. Using this method the AO Spacing of Curve – 4 was determined to be 9'. Using this information the following log data was acquired:

Rw = 0.054 @Tf [Thin bed corrected SP]
Rmf = 0.81 @ Tf
SN = 37 ohm-m [4674']
Rt (LAT) = 24 ohm-m [4674']
Rxo/Rt = {1.85□□(SN/LAT)-1.0} + 2 Rxo/Rt = 3.0
Rxo = 72 ohm-m

Log Analysis Sandstone [4666' to 4678']:
rxo = (Rmf/Rxo)^0.5 □rxo = 0.11
Sw(archie) = [(0.81/rxo^2) (Rw/Rt)]^0.5
Sw(archie) = 0.33
BVW = 0.036
Sw/Sxo = [(Rxo/Rt)/(Rmf/Rw)]^0.5 Sw/Sxo = 0.38
Sw(ratio) = [(Rxo/Rt)/(Rmf/Rw)]^0.625
Sw(ratio) = 0.30

At the base of the sandstone there is a low resistivity zone recorded on Curve – 4 which may indicate water. However, a close examination of the resistivity curves reveals the Curve – 4 is off depth 2.5' too high. The sandstone was later tested as a water-free completion.

The example presented illustrates the even with missing information that quantitative log analysis is possible with "OLD" E-LOGS when the geologist or engineer has some knowledge of how they work.

Exploration of the coupled relation between porosity and permeability using L-moments and L-comoments in the Ramsey sandstone, Ford Geraldine Field, Reeves and Culberson counties, Texas.

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Regional analysis of statistical distributions is a complex subject, which influences and is simultaneously influenced by many disciplines of the earth-system sciences. In particular, the study of magnitude and frequency and coupled relations of earth-system phenomena can be effectively investigated using L-moments and multi-variate L-moments (L-comoments). There is an enormous body of literature on "regional analysis" of hydrometeorologic data using L-moments. The authors write as if the reader is already familiar with many concepts of the trade; however, it is recognized that much of this literature is unfamiliar to geoscientists and petroleum engineers. This poster demonstrates a form of regional analysis with L-moment and L-comoment statistics using the lmomco, copBasic, and a still-private package in R.

What are L-moments and L-comoments? L-moments are defined through linear combinations of the expected values of order statistics (the statistics of ordered random variables and samples). L-comoments are similar defined through linear combinations of the expected values of concomitants of multi-variate random variables and samples. L-moments are direct analogs and have similar interpretations, but are not numerically equivalent, to the well-known product moments (mean, standard deviation, skew, and kurtosis). L-comoments have analogous

interpretations to correlation, covariance, co-skewness, and co-kurtosis.

The authors initiated development of the lmomcoexta package in R that provides for distinct and highly specialized visualization of L-moments and L-comoments in the context of general discordancy and cluster analysis. For this study, the bivariate data of porosity and permeability of a west Texas oil and gas field (Ford Geradline) are considered. However, the general application and visualization techniques of L-comoments used here are unknown in the literature, and the application of L-moments and L-comoments in regional analysis of porosity and permeability data is unprecedented. The results of the study show that these statistics can be combined in a framework that results in trend identification of a trend in the Ford Geraldine field that is consistent with that in the literature. Further, the analysis here should enhance the understanding of the coupled relation between porosity and permeability.

Can Hyperion Data Be Used to Map Carbonates and Iron Oxides in Sedimentary Strata?

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Hyperspectral remote sensing data, acquired over hundreds of narrow wavelength ranges, offer the potential for improved discrimination of rock and soil classes relative to more traditional datasets such as those generated by the Landsat Thematic Mapper. The Hyperion hyperspectral instrument is a high spectral resolution sensor mounted on the EO-1 satellite, and is capable of collecting images across the visible, near-infrared, and shortwave infrared (0.4 to 2.5 micrometers) with approximately 10 nanometer resolution. The purpose of this research was to use a High Arctic study area to evaluate the utility of Hyperion data in the quantitative mapping of mineral abundances, with a special emphasis on the detection and mapping of carbonates and iron oxides.

The Hyperion image used in this study, acquired for part of eastern Melville Island, Nunavut, was processed so that the cleanest 196 bands were converted from at-sensor radiance to reflectance. This conversion permitted the use of ground-derived reflectance spectra (including USGS library spectra) as a basis for mineral mapping. In this study, the mapping of relative iron oxide abundances using subtraction methods was successful. However, attempts to map carbonate mineral abundances using similar subtraction methods did not produce useful results. Analysis of both original and atmospherically-corrected Hyperion data indicated that the carbonate results were strongly affected by very high noise levels within the wavelength range of 2.0 to 2.5 micrometers, precisely the range within which diagnostic carbonate absorption features are normally found. In addition to subtraction techniques, the "spectral feature fitting" algorithm was tested in this research for use in mineral mapping. USGS end-member libraries were used to map individual ground-cover types including snow cover, healthy green vegetation, goethite, kaolinite, montmorillonite, and several varieties of hematite. Though the mapping of snow and green vegetation was successfully conducted through spectral feature fitting, none of the mineral classes of interest could be confidently mapped using this technique. Comparison between Hyperion data and laboratory spectra of Melville Island materials indicated that the noise present in original Hyperion data was the key limiting factor hindering the successful mapping of minerals in this study.

PETROLOGY OF THE RAILROAD DIKE, SOUTHEAST NEW MEXICO

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The Railroad dike has an exposed length of 48 km and a width as much as 23 m. The dike strikes E-W and has a reported age of 28 Ma. The dike is trachybasalt with phenocryst of olivine and augite in a groundmass of plagioclase with secondary chlorite and clinopyroxene, magnetite and ilmenite. The goal of this research is to determine whether the Railroad dike is compositionally similar to basaltic cobbles in the Ogallala Formation or whether these cobbles are related to basalts in the Raton-Clayton or Ocaté Volcanic Fields. Samples of the Railroad dike were analyzed via microscopic techniques, analyzed by inductively-coupled plasma atomic emission spectrometry, and compared with geochemical data for the other volcanic suites. A boulder collected near Amherst, TX plots on a TSA diagram as a tephrite basanite and on Harker diagrams did not appear to have strong association with the Railroad dike data. The Railroad dike is an alkali olivine basalt with ophitic texture and the boulder is vesicular olivine basalt The Railroad dike plots on a TSA diagram as a trachybasalt. Two samples from the Ocaté Volcanic Field plot on a TSA on the line between basalt and trachybasalt. Compositionally the Railroad dike has closer similarities with the alkali olivine basalt of the Ocaté Volcanic Field but does not have a strong trend when plotted on a Harker diagram for TiO_2 to SiO_2. However the boulder shows strong association when plotted on a Harker diagram for TiO_2 to SiO_2 with the Ocaté Volcanic field. Four samples from the Raton-Clayton Volcanic field plotted on a TSA as tephrite basanite. The boulder plots as a tephrite basanite as well. The boulder and the Raton-Clayton Volcanic field have strong association when plotted on a Harker diagram. Based on this data, the boulder appears to be closer related to the Raton-Clayton Volcanic field. However the Railroad dike did not show an association with the Raton-Clayton Volcanic field when plotted on the Harker diagram. When the Railroad dike was plotted with the Rio Grande Rift data on a Harker diagram, there was a strong association with three of the samples.

Magma Mingling and Mixing: Mafic Enclaves and Dikes in the Wooley Creek Batholith, N. California

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The tilted 159-156 Ma Wooley Creek batholith is a large, tilted intrusion with ~9 km of structural relief that provides a means to explore magma mixing and mingling at different structural levels. The pluton is zoned with structurally lowest gabbro, diorite, quartz diorite, & tonalite and structurally higher tonalite, granodiorite, & granite with sparse gabbro at contacts. Syn-plutonic mafic dikes and mafic magmatic enclaves (MME) occur throughout the batholith but are sparse in the lowest part and in greatest abundance in the central region. Dikes and disrupted

dikes are typically gabbro and diorite, whereas MME vary compositionally between gabbro and granodiorite.

Some enclaves are the result of disruption of mafic dikes in still-molten host magma, thus allowing for chemical and mechanical mixing. The mafic dikes are predominantly fine-grained and may have sparse plagioclase ± hornblende phenocrysts. The MME vary in shape from angular to ovoid and fusiform and in grain size from fine to medium with variable amounts of plagioclase, hornblende, & biotite 'phenocrysts'. At least some of these 'phenocrysts' are identical to crystals in the host rocks.

For the batholith as a whole, the MME have major & trace element compositions that are broadly intermediate between mafic synplutonic dikes and the enclave's host rock compositions. In this sense, MME compositions may represent mixing of existing magmas in the pluton with injected mafic (basaltic) magmas. Mixing probably began during disruption and dispersal of magmatic dikes. However, the fact that the groundmass mineral assemblage in the MME mimics that of their host rock type suggests that chemical exchange between host and MME magmas was commonly pervasive and continued to near-solidus conditions.

Depositional Framework of the Upper Pennsylvanian, Phylloid Algae - dominated Lower Winchell Limestone (Canyon Group), Palo Pinto County, Texas

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The Pennsylvanian was the height of the Late Paleozoic Ice Age. Pennsylvanian sedimentary packages called cyclothems were controlled by the waxing and waning of Gondwana glaciers. Cyclothem models from the North American Mid-continent during the late Pennsylvanian imply sea – level changes of up to 100m. The objective of this project is to document the sedimentary lithofacies and spectral gamma ray "chemofacies" of the lower Winchell Limestone (Canyon Group) to determine the evolution of depositional environments in response to a glacial cycle of rise and fall of sea – level. The focus of this research is on an exposure of the lower Winchell Limestone on US 180 in Palo Pinto County, Texas. The lowest 70cm of the exposure displayed coastal marine siliciclastics of the Wolf Mountain Shale. The overlying Lower Winchell Limestone is initiated with a 2m interval of phylloid algal wackestone exhibiting a cleaning – upward gamma ray profile. A 10cm shale break at the upper contact of the algal wackestone is overlain by very pure phylloid algal wackestone that displays the lowest gamma ray values in the section. Together, this succession indicates transgression and development of an open marine carbonate platform far removed from siliciclastic input. The overlying strata is mixed phylloid algal - siliciclastic packstone which displays increased siliciclastic input and exhibits a "dirtying - upward" gamma ray profile. This is then topped by a reddish fossiliferous grainstone underlying a 50cm organic shale that exhibits the highest gamma ray values in the section, which is indicative of a regression and exposure of the platform. Overlying the lower shale break, smaller scale cycles of clean phylloid algal wackestone and thin (1-10cm thick) black shale partings are noted. These cycles represent short - term intervals of carbonate production and sediment starvation. It is here proposed that minor wet – dry climate changes are superimposed onto the longer term glacial – interglacial sea – level cycle. In this model, brackish water plumes during wet periods stratify the water column causing anoxic bottom conditions, shutting down phylloid algal carbonate production. Maximum carbonate production then resumed during dryer periods.

Thermodynamic and Kinematic Analysis of Supercells using High Resolution In situ Data from Texas Tech StickNet Instrument Systems.

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In May and June of 2009 and 2010, over 100 scientists, students and volunteers embarked on the largest tornado research project in history: The Verification of the Origins of Rotation in Tornadoes EXperiment 2 (VORTEX2). Texas Tech played an integral role in this project by deploying a total of 650 StickNet platforms, designed specifically for safely measuring crucial thermodynamic and kinematic variables within hostile regions of storms. Of critical importance to the numerous scientific objectives sought out in VORTEX2 is the observation and analysis of the thermodynamic characteristics of both tornadic and non-tornadic supercells. Numerous studies have revealed that streamwise vorticity generation due to baroclinity is critical to low-level mesocyclogenesis and tornado genesis. However, recent observational studies have shown that supercells with relatively small thermodynamic deficits between the inflow and both the rear flank and forward flank environments are more likely to produce longer lived and violent tornadoes than those with large deficits. Other studies have shown that individual storm scale environments exhibit substantial variability, thus making it difficult to adequately diagnose the state of a storm with limited observations. Although much has been learned from these studies, a clear relationship between baroclinity and tornado genesis remains elusive. In this presentation, StickNet data from several VORTEX2 cases will be used to analyze the thermodynamic and kinematic structure of two mature tornadic supercells.

Provenance Studies in the Permian aged San Angelo Formation, near Bronte, Texas: Implications for a trans-mountain fluvial system linking Africa to Texas

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Quartz-rich sandstones in the San Angelo Formation, Coke County, Texas were analyzed to determine the provenance and transport medium of detrital sediments. Hand samples are loosely packed coarse-grained aggregates of rounded to sub-rounded grains of pebble size or smaller. Microscopic observations in thin section show the rocks to have a high porosity, broad distribution of grain shape and size, almost no cement, and a mineral assemblage dominated by quartz, with

subsidiary clays and muscovite mica, hematite and minor plagioclase. The heavy and accessory mineral assemblage was volumetrically very small (<0.1 vol.%) and consisted mainly of zircon. On the basis of Folk's classification the samples are quartz arenites. Scanning electron microscope imaging of zircon shows that they have oscillatory zoning indicative of an igneous source and are euhedral to sub-hedral in shape. The architecture of the deposits is indicative of a fluvial stream environment of sediment transportation and deposition. In the Late Paleozoic central Texas was located on the northern margin of the closing Rheic Ocean, during collision between northern Gondwana (Yucatan and South America) with southern Laurentia. The presence of detrital zircon with Pan-African ages in parts of the San Angelo Formation suggests that the studied deposits may represent fluvial, or river deposits of sediment transported from the Pan-African margin to Central Texas during the Middle Permian.

Forecasting and the Public

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The main purpose of this research is to establish the differnces of opinion and outlooks of forcasters and the public, and to begin to bridge the gap of understanding betwwen the two. By examining two cold events in the month of Febuary and conducting a survey of 100 persons the dissimilarity is ever so established.

Schroeder J.L. et al. (2005) ESPL 210-216

Emplacement and Fabric Development in the Wooley Creek batholith, Klamath Mountains

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The Wooley Creek batholith is a 161-156 Ma tilted intrusion emplaced into a series of accreted terranes in the Marble Mountains Wilderness, N. CA. Previous work has demonstrated that the WCb is complexly zoned, with a structurally deeper section of gabbro, diorite, quartz diorite, and tonalite, and a structurally shallower section of diorite, quartz diorite, tonalite, granodiorite and granite [1].

The WCb may be divided into three structurally distinct units, a lower zone (northern) of marginally N-S striking hypersolidus foliations, an upper zone (southern) of both E-W and margin-parallel hypersolidus foliations, and a deformed intermediate zone with NE striking hypersolidus foliations, abundant synplutonic dikes, and mafic magmatic enclave swarms.

The lower portion of the pluton is sheeted at the metric to kilometric scale, with foliations parallel to sheet margins. In contrast, the upper portion of the pluton is texturally and compositionally much more homogeneous. New amphibole trace element geochemistry within the upper unit of the pluton indicates widespread chemical communication within a large partially molten chamber.

Aligned laths of plagioclase and amphibole define magmatic foliations where present. Late, isotropic phenocrysts of biotite grew over the magmatic foliation.

These observations are consistent with batholith-scale fabric formation due to emplacement-related processes. NS trending fabrics in the NE record compressive strain associated with the emplacement of subsequent sheet-like intrusions. Magmas of the upper WCb rose through and around these sheets and before reaching its final level of emplacement.

[1] Barns, C.G., 1983. Petrology and upward zonation of the Wooley Creek Batholith, Klamath Mountains, California. J. Pet., v. 24, part 4, 495-537.

Lineaments of Southern High Plains: possible indicators of recent faulting

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Through the analysis of topographic data, a number of parallel lineaments trending approximately N37°E across the Southern High Plains (SHP) of Texas have been identified. Although some of these lineaments appear to serve as drainage, they trend roughly perpendicular to the down slope direction of the SHP and the larger streams in the region. The source of formation of these lineaments is not known, however they appear across the entire Southern High Plains.

The focus was a portion of two lineaments in Northern Hockley County, Texas that are approximately 2.5 km apart. The particular lineaments appear to have created an almost perpendicular bend in a small ephemeral stream, causing the drainage to flow nearly perpendicular to the trend of the Southern High Plains. Subsequent gravity profiles show approximately a half a mGal gravity anomaly across each of these lineaments. The short wavelength of said anomalies implies a gravity contribution from a shallow source; however, the small density contrasts common for the shallow sediments in the area cannot account for the entire 0.5 mGal difference in gravity. Well log analysis shows a lithology offset of approximately 12.5 meters at over 1100 meters depth along the lineament. The linearity to the features, extending for tens to over a hundred kilometers, (the latter is seemly comprised of smaller en echelon lineaments), suggests regional faulting in the subsurface to a significant depth. The best fit gravity model indicates the possibility of growth faulting. An electromagnetic survey found shallow, high conductivity anomalies associated with the lineaments. It is believed this conductive high indicates that these lineaments may result in the erosion of the caliche layer which could provide a conduit for infiltration.

QUARTZ PREFERRED ORIENTATION AND ITS IMPACT ON THERMAL ANISOTROPY IN SANDSTONE AND QUARTZITE

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Thermal conductivity may be defined as the rate of heat transfer through a material. Many crystalline materials display variable thermal conductivity as a function of crystal orientation; such materials are referred to as thermally anisotropic. Quartz, one of the most abundant minerals in the Earth's crust, is on such mineral. Therefore, the thermal conductivity of quartzite, a rock defined as having >95% quartz, should vary as a function of quartz crystal preferred orientation. If the preferred orientation of

quartz in quartzite can be measured, it should be possible to model the thermal properties of the rock and estimate its potential as a latent heat-source for geothermal energy production.

Quartzites with varying preferred grain orientation were sampled along two traverses in central New Mexico. Quartz grain orientation was measured using Electron Back Scatter Diffraction (EBSD). In one traverse, increasing quartz preferred orientation was measured with increasing proximity to a crustal-scale deformation-shear zone. In the second traverse, an increase in crystal preferred orientation was observed with increasing proximity to a large granite intrusion. Using the thermal properties of quartz and the measured quartz preferred orientation, calculations show that the thermal conductivity of the samples should increase with proximity to the shear-zone and the granite intrusion.

A steady-state method was used to calculate actual thermal conductivity values. If measured thermal conductivity of quartzite does vary as a function of measured quartz preferred orientation, the results may provide the basis of a model for identifying potential sites for passive geothermal energy plants.

DIACHRONOUS HYPERSOLIDUS DEFORMATION DURING REPEATED MAGMA INJECTION: FIELD OBSERVATIONS FROM THE TILTED WOOLEY CREEK BATHOLITH

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New field and structural observations from the 158-154 m.y.o. (U/Pb TIMS), Wooley Creek batholith, Klamath Mountains, CA is presented. The WCb is tilted to the south and exposes over 15km of structural relief. The intrusion may be divided into a northern (deeper) gabbroic/diorite/quartz diorite zone, a central, complexly sheeted zone of quartz diorite/tonalite containing abundant mafic magmatic enclaves (MME's), enclave swarms, and disrupted/deformed mafic dikes, and a aouthern (shallower) zone of minor gabbro, quartz diorite, tonalite, granodiorite, and granite. All foliations are hypersolidus in nature and are defined by laths of plagioclase and amphibole.

Fieldwork in the Cuddihy Basin yields the following observations and interpretations related to the central quartz diorite/tonalite 'host' magma. At least seven distinctive intrusive episodes (1: early cognate xenoliths; 2: tonalite/quartz diorite host magma; 3: various coarse-crystalline MME's; 4: fine-crystalline mafic dikes; 5: net-veined fine- to medium-crystalline mafic dikes; 6: folded amphibole + biotite + plagioclase-phyric dikes; 7: late, leucocratic veins and three distinctive hypersolidus foliation-forming events occurred in Cuddihy Basin. The oldest foliation occurs in coarse-crystalline cognate xenoliths of quartz diorite contained withint the host magma. Foliations are perpendicular to host foliations and are truncated at the margins of the xenolith. The second set of foliation is N-NE trending and occurs within the host magma. Swarms of mafic enclaves are aligned parallel to this fabric and are cut by late fine-crystalline mafic (gabbroic to quartz dioritic) dikes. These dikes vary in orientation and are boudined and/or folded within the hypersolidus foliation plane of the host. Where these 'ribbon dikes' are folded, an axial planar hypersolidus foliation occurs in both the dikes as well as the host, representing the last fabric to have formed.

Presently it is not clear if the fabrics are related to either regional deformation present during emplacement or emplacement related flow. Both are consistent with NS extension and EW shortening. Whether these processes of deformation held constant or varied in strength throughout the time of multiple injections of host magma is still to be determined.

An Examination of the Structure of Three Tornadoes Using High-Frequency Ka-band Mobile Doppler Radar

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Knowledge of the vertical structure of tornados is of great importance to meteorologists and civil engineers alike, albeit for different reasons. Meteorologists' interest in the vertical structure of tornadoes stems from a desire to better understand and predict the genesis, movement and dissipation of tornadoes, while the engineering community is interested in building structures that are better suited to withstand the winds of a tornado. Both the laboratory experiments as well as the numerical simulations have shown that structure of the tornado is highly dependent on the swirl ratio.

The Texas Tech University Ka-band radars (TTUKa) are two new tools that are well suited to the study of tornado vortex structure at a very fine-scale spatial resolution. The first radar was completed in the spring of 2009 in time to participate in the first year of the VORTEX2 field project. The second radar was finished in late winter 2010 and was available for the second year of the project. During the course of the project, the TTUKa radars successfully scanned ten tornadoes.

This study will focus on the horizontal structure of three tornadoes using data collected by the TTUKa radars during VORTEX2. The three tornadoes that will be examined in this presentation occurred on June 13, 2010 tornado near Booker TX, May 18, 2010 near Stinnett, TX and May 25, 2010 near Tribune, KS. All three of these tornadoes were rated EF-0 on the Enhanced Fujita Sale. The evolution of the vortex structure will be diagnosed using the Ground- Based Velocity Track Display (GBVTD) technique of Lee et al.[1]. The appropriate scaling of tangential winds outside the radius of maximum wind for these weak tornadoes will be discussed as well as the variability of radial flow. In addition, the swirl ratio of the Stinnett tornado will be calculated and placed into the context of current conceptual models.

[1] Lee et al. (1999) *Mon Wea Rev.* **127**, 2419-2429.

NATURE AND ORIGIN OF QUARTZITE PEBBLES IN THE OGALLALA FORMATION, SOUTHERN HIGH PLAINS, TEXAS

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The Ogallala Formation consists of sand and gravel deposited during Miocene time as a result of uplift of the southern Rocky Mountains in New Mexico. These sediments were carried into Texas by one or more river systems. Quartzite pebbles are one of the most common and widespread clast types found in Ogallala stream gravels. A representative sample of quartzite pebbles was

collected from an outcrop of Ogallala gravel in Garza County and thin-sections were prepared from examples of each quartzite type. The quartzites vary widely in texture and mineralogy. Some exhibit uniform polygonal granoblastic texture, while others have sutured recrystallized grain boundaries, foliation, and high-strain textures. Most contain minor amounts of muscovite and magnetite; a few contain orthoclase or microcline. Typical index minerals include chlorite, epidote, garnet, kyanite, andalusite, and sillimanite indicating that the quartzites originated from rocks spanning a broad range of metamorphic zones. The wide variability in strain textures and mineral assemblages indicate that the quartzites were derived from a diverse provenance. The source terrain must have been Proterozoic metamorphic rocks exposed in one or more of the mountain ranges in northern or central New Mexico; there are no other regional sources for quartzite. It seems certain that the source areas must have been on the east-facing sides of these ranges, because the west-facing sides now (and presumably in Miocene time) drained westward into the Rio Grande rift valleys, not eastward. Much of the exposed Proterozoic metamorphic terrain in these ranges consists of schist and amphibolite; quartzites comprise only a small percentage of the outcrops. However, the Hondo Group, exposed in the Rincon Mountains has a thick series of quartzites, and these may have been the source of the Ogallala gravel.

Surface Charge at the Rutile-water Interface in LiCl media.

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Rutile (TiO_2) is a mineral of great interest because it is in many of the products that humans use every day. It is used in applications such as sunscreens, paints, ointments, toothpaste, as well many others [1]. Rutile is naturally found in soils, so the chance of coming in contact with natural waters is very high. One way to study rutile is to test the surface charge created when coming into contact with ions. Testing ions with the same valence charge is a control we can use to test the effect of other characteristics such as ionic radius size, ionic strength, and the effects of changes in temperature. Using an autotitrator, we tested the reaction between lithium chloride (LiCl) and rutile. Results showed that Li^+ generated a greater surface charge than Na^+, K^+, and Rb^+ ions [2] which have the same charge, but larger ionic radii. This suggests that ions with smaller ionic radii will produce a greater surface charge than ions of the same charge with larger ionic radii. This can be explained by understanding that ions with smaller radii can fit more of themselves in a specific amount of area. Each ion has the same charge, making the total charge of the reaction higher. The results also show that a higher temperature and a higher ionic strength each increase the surface charge of the reaction.

[1] Chen et al. (2007) *Chem. Rev.* **107**, 2891-2959.
[2] Ridley et al. (2009) *Geochim. Cosmoc. Acta.* **73**, 1841-1856.

Textural and Mineralogical Characterization of Rare Earth Mineral Assemblages in Carbonatites from northwest Bull Hill, Bear Lodge Complex, northeast Wyoming

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Rare earth elements (REEs) are a vital commodity utilized in numerous items such as computers, cell phones, headphones, televisions, airplanes, security systems, cars, generators, wind turbines, lasers, and military applications. China, the world's leading REE producer, has begun cutting exports. Since the United States is 100% reliant on REE imports, characterization of known United States REE deposits is crucial to progress from identified deposits to producing deposits. The Bear Lodge Complex is one of a group of igneous complexes that extend along a N75W trend from the northern Black Hills, through Wyoming, and into Montana. The Bear Lodge rare earth deposit is hosted by a swarm of carbonatite dikes located at Bull Hill in the north-central area of the complex. Detailed mineralogic, textural, and petrologic characterization of the north-western extension of this REE-deposit has been completed. Traditional optical microscopy of the fibrous interlocking assemblages of REE minerals, barite, strontianite, and other accessory phases is hampered by low resolution and limited magnification.

Secondary electron imaging, backscatter electron imaging, and energy-dispersive x-ray spectroscopy have been employed for textural characterization and mineral identification of REE bearing assemblages found in a carbonatite sample from the north-western extension of the Bear Lodge rare earth deposit.

Verification of Supercell Cold Pools in High-Resolution WRF Simulations using StickNet In Situ Data

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Numerical model errors in supercellular cold pools at high resolution are being investigated in the Weather Research and Forecasting (WRF) model, initialized with conventional Doppler radar data using ensemble Kalman filter (EnKF) assimilation techniques. High-resolution simulations are necessary to resolve individual updrafts. However, as spatial resolution increases, the simulation becomes prone to systematic errors due to assumptions within each parameterization scheme. For instance, the default microphysical parameterization used in most numerical simulations are bulk single-moment, which tend to overestimate the strength of the cold pool. This study will investigate the biases present within supercellular cold pools generated by common microphysical parameterizations (single-moment and double-moment schemes) used in the WRF model. Verification of the numerically simulated supercell cold pool will use data gathered during the second Verification of the Origins of Rotation in Experiment (VORTEX2), especially from the StickNet platforms, which spanned the entirety of the precipitation core in numerous cases. Using these high-resolution data for verification allows for a more precise error calculation both spatially and

temporally. This verification will allow for determining if certain parts of the model-developed cold pool are more susceptible to error.

Effects of chemical abrasion on elemental and isotopic partitioning within zircon using Sensitive High Resolution Ion Microprobe analysis

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The application of chemical abrasion to zircon geochronology has proven to be an effective method of increasing the accuracy of U-Pb dating using Thermal Ionization Mass Spectrometry (TIMS) by lowering the discordance due to Pb loss. Chemical abrasion removes zircon domains which have experienced Pb loss and thermally anneals the grains in order to repair radiation damage experienced by the lattice.[1] To date, there have been no studies of the effects of chemical abrasion on zircon geochronology using Sensitive High-Resolution Ion Microprobe analysis. Zircon samples from the Red Bluff Granite Suite in West Texas were treated using standard chemical abrasion techniques and analyzed at the USGS Standford SHRIMP-RG laboratory. U-Pb isotopes from both abraded and non-abraded zircon gave an igneous age of 1109 +/- 27 Ma. MSWD=1.8 with the abraded zircon showing little discordancy and the non-abraded zircon being much more discordant. REE patterns differed significantly between the abraded and non-abraded samples with higher abundances of both LREEs and HREEs in the non-abraded samples. Eu and Cs anomalies also varied between samples. The data suggests that the use of chemical abrasion can be an effect way to increase accuracy and concordancy of U-Pb dating using SHRIMP analysis. It also clearly displays that chemical abrasion has a significant effect on the concentrations of REEs within zircon grains that have been treated.

[1] Mattinson et al. (2005) Chemical Geology. **220**, Vo1 1-2, 47-66

Stratigraphy and paleontology of the Tornillo Group (Upper Cretaceous-Eocene) in southern Big Bend National Park, Texas.

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The Tornillo Group is widely exposed in Big Bend National Park in West Texas. These strata are of tectonic and paleontological significance because they were deposited during the Laramide Orogeny and contain a succession of Late Cretaceous through Eocene faunas. The Tornillo Group has been studied extensively for nearly a century; however, remote exposures south of the Chisos Mountains in the Park have not been extensively explored. This region was surveyed in the present study for new vertebrate fossil sites and previously unexplored exposures of the Tornillo Group. As a result of these surveys three major exposures of the Tornillo Group have been chosen for detailed stratigraphic analysis. Several new fossil localities were discovered and a site was found that had previously been excavated by B. Brown and R.T. Bird of the American Museum of Natural History in 1940. The goal of the present study is to produce detailed correlatable stratigraphic sections of the Tornillo Group in southern Big Bend National Park and to document new fossil sites in the Park.

TTUKa Mobile Doppler Radar Observations of Multiple Rear-Flank Downdraft Surges and an Intense Near-Surface Vortex

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The 2010 campaign of the second Verification of the Origin of Rotation in Tornadoes Experiment (VORTEX2) marked the first occasion two Ka-band mobile Doppler radars deployed in tandem in a severe storm environment. The TTUKa radars utilize a 0.49 degree beamwidth and pulse compression techniques to achieve less than 35 m azimuthal, vertical, and range resolution. The sensitivity of the TTUKa radars provide a unique perspective of the evolution and structure of boundaries relevant to the storm scale, and potentially, the tornado scale.

TTUKa dual-Doppler analysis of a pretornadic, near-surface mesocyclone occurring on 18 May 2010 near Dumas, Texas will be presented. Dual-Doppler data were collected continuously for 18 minutes with a 3.5 km baseline, allowing the evolution of multiple rear-flank downdraft (RFD) surges to be documented. Additionally, a brief, intense near-surface vortex was observed at the apex of one RFD surge allowing the kinematic character of individual surges to be compared in an attempt to identify circulation intensification mechanisms.

Facies Anaysis of the Stockwether Formation in Relation to Global Glaciation Levels.

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The Late Pennsylvanian and Early Permian was an icehouse interval characterized by waxing and waning of ice sheets across Gondwana. This resulted in glacial – eustatic transgression and regression in the tropics, including the Eastern Shelf of the Midland Basin. During interglacial episodes, transgression across the Eastern Shelf allowed extensive carbonate depositional systems to expand, including the inner platform outcrop belt of north – central Texas. The goal of this project was to examine the carbonate lithofacies of the Lower Permian Stockwether Limestone at four outcrop sections in north – central Texas to reconstruct the change in environment of deposition across the platform .

Examination of the marine fossils present in thin sections made it was possible to break down the depositional environment into distinct periods of sea level rise and fall. Some of the fossils that were used to determine depositional environment included fusulinids, phylloid algea, *tubiphytes*, trilobites, staffellids and crinoids. By observing concentrations and type of the fossils present it was possible to determin the marine depositional environment flucuated from calm, clear open marine basins ranging from 15-30 meters deep to calm shallow coastal regions and continued to coastal flood plains throughout the duration of deposition of the Stockwether Formation.

Paleontology of the Horses from The Blanco Formation

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The Pliocene-Pleistocene aged Blanco Formation in Crosby County, Texas is the type locality for the Blancan Land Mammal Age[1,2]. Along with other typical Blanca fauna, fossils of three sympatric species of horses have been recovered from the Formation in over a century of excavations. Horse taxonomy and phylogeny are frequently revised, as a result of poor resolution in the few distinct characters. As such, the Blanco Formation horse specimens require a review in the light of a current understanding of horse phylogeny. A recent review provides an up-to-date perspective on the taxonomy of the Blanco Formation horses, and was based on published descriptions and computed tomography of specimens.

[1]Dalquest, W. W. (1975) Vertebrate Fossils from the Blanco Local Fauna of Texas, *Occasional Papers The Museum Texas Tech University* 30, 1-52.
[2]Holliday, V. T. (1988) Mt. Blanco revisited: Soilgeomorphic implications for the ages of the upper Cenozoic Blanco and Blackwater Draw Formations, *Geology* 16, 505-508.

Winter Storm 01/29/11

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On January 29, 2011 a series of measurements were taken from the atmosphere by a radiosonde during a winter storm. The storm was located in Madison County, Alabama. These measurements include temperature, pressure, relative humidity, latitude, longitude, geometric height, and wind speed and direction. The software used to obtain the data is iMet-3150 software and the software to interpret the data is microsoft excel and Python. Four radiosondes were launched at three hour intervals starting at 00 Zulu.

The data obtained from the 03Z launch shows an echo top between 9-10 km and a cloud base around 1km. At the time of launch there was rimming and a large amount of snowfall. Some original data was removed due to bad temperature readings. 06Z data shows significant rimming at the time of launch and moderate snowfall. The echo top was around 5-6 km. The data obtained from the 09Z launch had a lesser amount of bad data with light snow at launch and a 3.5-4 km echo top. The data obtained from the 00Z launch was not used due to the greater amount of unusable data.

IS THE LATEST DEVONIAN HANGENBERG EVENT PRESENT IN THE WOODFORD SHALE (LATE DEVONIAN- EARLY MISSISSIPPIAN) IN SOUTHERN OKLAHOMA?

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The latest Devonian Hangenberg event is a global extinction that was associated with increased ocean anoxia related to sea level rise. A sea level rise attributed to temperatures increasing and melting ice caused the oceanic oxygen level to decrease and these anoxic waters to transgress onto carbonate platforms and to extinguish marine organisms. The Hangenberg event typically appears as a black shale unit with a short-lived major positive $\delta^{13}C_{org}$ excursion (+4 $^{0}/_{00}$) within the otherwise carbonate–dominated sections in Europe and North Africa. The Hangenberg event also increased CO_2 that contributed to global cooling and a large glaciation event took place around the Devonian/ Carboniferous boundary.

In southern North America, the Late Devonian-Early Mississippian Woodford is mostly organic-rich black shale with lesser chert and phosphate in the upper part of the unit. Even though the Hangenberg event could not be recognized lithologically in the black shale section, conodont faunas from southern Oklahoma indicated where it should lie in the section. A detailed suite of samples were taken from beds in the upper Woodford associated with latest Devonian to earliest Mississippian conodont faunas at the Hass G section, near Ada, Oklahoma for carbon isotope analysis of the organic material with purpose of finding the major $\delta^{13}C_{org}$ excursion associated with the Hangenberg event.

A slight, approximately 1 $^{0}/_{00}$, decrease in $\delta^{13}C_{org}$ occurs at the base of the Mississippian at the level indicated by the appearance of *Siphonodella sulcata* in the Hass G section. This may represent the upper decline at the top of Hangenberg event, but its small size and absence of an increase in $\delta^{13}C_{org}$ lower in the section, makes this unlikely. We suggest that the Hangenberg event is completely missing at a disconformity associated with the thin phosphatic zones at the base of the Mississippian.

Greenstone rocks in the Mimbres valley, central New Mexico: geological significance for archaeological Provenance

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The Mimbres Valley in New Mexico was a center of the Mogollon culture which was prevalent throughout much of the American southwest ~1200 BC to ~1200 AD. Within the Mogollon lithic toolkit (projectile points, scrapers, and cutters) were hafted greenstone axe heads. Due to the relative dullness of the cutting edge and availability of sharper lithics it has been suggested that the axes were ceremonial items. Such individual items, which many have held significance only to particular Mimbres communities, could provide a tool for modeling intercommunity trade and interaction. If the provenance of greenstone materials can be identified, then models for exclusivity and specialization of greenstone tools and their trade between Mogollon communities can be developed. One of the most probable sources of greenstone rock in the Mimbres valley is a transect of ~1.65 Ga mafic to ultra mafic rock near San Lorenzo. Samples have evidence of an igneous mineral assemblage that included plagioclase + clinopyroxene + orthopyroxene + olivine + amphibole. Many samples also have localized schistose domains and have evidence of hydrothermal veining. Metamorphic minerals include chlorite, epidote, amphibole and quartz.

Compositional analysis confirms that the lithologies are mafic to ultra-mafic and probably originate in the mantle. Major and trace element discrimination diagrams indicate the magmas were tholeiitic, and may have evolved in an arc environment. However, spider diagrams of chondrite and MORB normalized trace element concentrations show a spread of values between MORB and OIB, particularly for the more mobile large ion lithophile elements. This suggests that post-crystallization hydrothermal affects probably altered the concentrations of some trace elements. A consequence is that it is currently not possible to discriminate between MORB and OIB sources for the rocks on a basis of composition alone. On the other hand, the samples show a broad diversity of rock-forming mineral assemblages, textures and compositional variation and the dataset provides a baseline against which the properties of greenstone tools with a well constrained provenance should provide information on whether the raw materials for tool fabrication was sourced in the Mimbres valley

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