NEW MEXICO GEOLOGICAL SOCIETY
2014 SPRING MEETING

Friday, April 11, 2014
Macey Center
New Mexico Institute of Mining and Technology
Socorro, New Mexico

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NMGS EXECUTIVE COMMITTEE
President: Virginia McLemore
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Adam Read

ORAL SESSION CHAIRS:
Jeffrey Amato, Dan Koning, Greg Mack, Frank Ramos, Thomas Williamson

Schedule of Events –NMGS Annual Spring Meeting, April 11, 2014
Registration 7:30 am to Noon, Lower Lobby

8:30-8:45 Welcome and Introduction- Auditorium

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Auditorium
Chair: Jeffrey Amato
8:45 AM - 10:00 AM

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— *8:45 AM - 9:00 AM*

^{40}AR/^{39}AR MUSCOVITE THERMOCHRONOLOGY AND MONAZITE GEOCHRONOLOGY OF NEW MEXICO PEGMATITES
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— *9:00 AM - 9:15 AM*

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— Jeffrey M. Amato, Rosemary Williams, and George Gehrels
— *9:30 AM - 9:45 AM*

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— *9:45 AM - 10:00 AM*

10:00-10:30 BREAK and POSTER VIEWING, Upstairs Lobby

Session 2: Hydrology, Geomorphology, and Paleosols
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Chair: Dan Koning
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HYDROGEOLOGIC CONTROLS ON EARLY TRAVEL THROUGH THE JORNADA DEL MUERTO, NEW MEXICO
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— *8:45 AM - 9:00 AM*

RECHARGING THE TULAROSA BASIN
— Ethan A. Mamer, B. Talon Newton, Stacy Timmons, Daniel J. Koning, and Lewis A. Land
— *9:00 AM - 9:15 AM*

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— *9:15 AM - 9:30 AM*

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— Stacy S. Timmons
— *9:45 AM - 10:00 AM*

10:00-10:30 BREAK and POSTER VIEWING, Upstairs Lobby

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Auditorium
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— *10:30 AM - 10:50 AM*

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— Douglas Bland and Susan Welch
— *10:50 AM - 11:10 AM*

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Awards Ceremony and Keynote Presentation in Auditorium

1:30-2:30

Kate Giles, University of Texas at El Paso

SYNERGY BETWEEN ACADEMIA AND THE FOSSIL FUEL INDUSTRY IN NEW MEXICO

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3:30-5:30
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Abstracts

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Coeval Deposition of Carbonate and Associated Sedimentary rocks at 1.25-1.23 Ga in Texas, New Mexico, and Arizona: Expanding Our Understanding of Grenville Tectonism in the Southwest U.S.

Jeffrey M. Amato[1], Rosemary Williams[1] and George Gehrels[2]

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Exposures of Grenville-age (1.3–1.1 Ga) sedimentary rocks in the southwest U.S. include outcrops in the Llano Uplift, Van Horn area, and Franklin Mountains of Texas, the Burro Mountains in southwest New Mexico, the Apache and Unkar Groups in Arizona, and the Pahrump Group in Death Valley. Igneous activity includes arc magmatism from ~1325–1150 Ma and 1150–1120 Ma (Mosher et al., 2008). The Grenville orogeny may have ended around 1120 Ma. Widespread diabase magmatism and coeval silicic intrusions range from 1100–1075 Ma and may reflect an episode of plume magmatism or lithospheric delamination with associated partial melting of the crust to form granitoids (Bright et al., 2014).

We have obtained U-Pb zircon ages from sedimentary rocks and interbedded tuffs from the Transmountain Road area of the Franklin Mountains, west Texas. These include, from top to bottom: (1) Thunderbird Rhyolite, 1143 ± 13 Ma (previously dated at 1111 ± 43 Ma; Roths, 1993); (2) Tuff in the Castner Marble, 1232 ± 6 Ma (previously 1251 ± 46 Ma and 1260 ± 20 Ma, Pittenger et al., 1994); (3) a carbonate sandstone with a youngest population at 1251 ± 16 Ma and other peaks at 1478 Ma, 1630–1717 Ma, and one grain at 2330 Ma. This sequence was intruded by the Red Bluff granite at 1124 ± 4 Ma (Howard, 2013; previously dated at 1120 ± 35 Ma, Shannon et al., 1997). Detrital zircon U-Pb ages were obtained from Mesoproterozoic sedimentary rocks in central Arizona. The Dripping Spring Quartzite is part of the Apache Group and underlies the Mescal Limestone. Maximum depositional age (MDA) for this unit is 1258 ± 19 Ma and the MDA in the overlying Troy Quartzite is 1252 ± 8 Ma.

Williams and Amato (this meeting) dated Grenville-age sedimentary rocks that include marble and calcite-bearing metasedimentary rocks. These have MDAs of 1230 ± 11 Ma and are thus coeval with the Castner Marble. Thus we correlate the carbonates in the Franklin Mountains of Texas and Burro Mountains of New Mexico, and although they may be slightly younger than the Mescal Limestone of the Apache Group of Arizona, they probably are part of the same depositional system (possibly also including the Bass Limestone of the Grand Canyon and the Crystal Spring Formation of Death Valley interpreted to have been deposited in the back-arc of a subduction zone associated with Grenville convergence. These correlations expand on Shride (1967) who originally correlated some of these carbonate units.

References:

- Bickford, M. et al., 2000, GSA Bulletin, 112:1134-1148.
- Bright, R. et al., 2014, Lithosphere, in press.
- Howard, A., 2013, [M.S. thesis]: U. Colorado.
- Mosher, S., et al., 2008, Geology, 36: 55-58.
- Pittenger, et al., 1994, J. Sedimentary Res., B64: 282-297.
- Roths, P. J., 1993, GSA South Central Section Field Guide, 11-35.
- Shannon, W., et al., 1997, J. Petrology, 38: 1279-1305.
- Shride, A.G., 1967, U.S.G.S. Prof. Paper 566.

A GEOGRAPHIC INFORMATION SYSTEMS AND REMOTE SENSING GEOHERITAGE INVESTIGATION OF THE UPPER PECOS RIVER VALLEY.

Amanda D Aragon[1], Michael S. Petronis[1] and Joseph P. Zebrowski[1]

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The purpose of this multidisciplinary study is to evaluate changes in land use practices pertaining to cultural development since early 1970s in the Upper Pecos Valley in Northern New Mexico, USA. The investigations will consider historic patterns in the progression of land management practices, political events, and agricultural development using Geographic Information System (GIS) and Remote Sensing techniques. A comparative investigation from a series of satellite imagery will be used to examine changes in the land use and conditions of the study sites over time. Landsat satellite images from the 1970s to present will provide multispectral measurements of vegetation coverage and vegetation health in both growing and non-growing sessions. Changes to the local environmental conditions in the area will also be evaluated using records of climate, precipitation, stream gage data, oral history, and historical records. The need to develop a further understanding of the Pecos River Valley in North Central New Mexico and its land use practices will aid in conservation efforts and development of this physical and cultural landscape. Study results will also be used to demonstrate the local community the value of modern science investigations in addressing local concerns. In addition, the results from this study will be integrated in to the Ribera Community Cultural Center and Pecos Historic Park.The purpose of this multidisciplinary study is to evaluate changes in land use practices pertaining to cultural development since early 1970s in the Upper Pecos Valley in Northern New Mexico, USA. The investigations will consider historic patterns in the progression of land management practices, political events and agricultural development using Geographic Information System (GIS) and Remote Sensing techniques. Landsat satellite images will provide multispectral measurements to interpret vegetation coverage and health in both growing and non-growing sessions. Conditions of change in the area will also be evaluated using records of climate, participation, stream gauges, oral history and historical records. Further understanding of land use practices will aid in conservation efforts and development of this physical and cultural landscape. Study results will also be used to demonstrate the local community the value of modern science investigations in addressing local concerns.

URANIUM OCCURANCE IN HONDO-SECO GROUNDWATER, TAOS COUNTY, NM

Tony Benson[1], William Stone[2] and Ron Gervason[3]

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Uranium has been tested in domestic water wells in the Arroyo Hondo, Des Montes, Arroyo Seco and El Salto neighborhoods of central Taos County. Analyses funded by the Taos Soil and Water Conservation District have found spots south of the Rio Hondo that approach or exceed EPA drinking standards of .030 mg/L.

Uranium occurrences are in alluvial fan clastic facies extending from the Sangre de Cristo Mountain westward for 10 miles to the Rio Grande Gorge. The uranium source rock is probably the mid-Tertiary granitic plutons or late-stage rhyolitic dikes in the mountain headwaters that eroded into the Tertiary-Quaternary alluvial fan complex.

Varying water levels over time may have allowed the phreatic oxidized zone to develop uranium in a soluble form that is carried downward to the reducing aquifer environment similar to commercial uranium deposits elsewhere. The process is complicated by local wells of heavy drawdown, periods of drought, a fractured underlying dacite volcano, fault zones, acequia recharge, gaining and losing stretches of the adjacent Rio Hondo, mountain-front undercharge, or other factors.

Health effects of higher uranium concentration may be remediated depending on concentration and required treatment scale by various methods. These methods can be as simple as filters for tap water for domestic use to larger reverse osmosis treatments or ion exchange systems for community mutual domestic wells.

THE INTERPLAY BETWEEN THE ENERGY INDUSTRY AND ACADEMIA IN HYDROCARBON EXPLORATION IN THE RIO GRANDE RIFT

Bruce A. Black

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The synergy between the Fossil Fuel Industry and academia is not a static or linear exchange process. The starts and stops in oil and gas exploration and the spurts of academic geologic knowledge form curves through time that are often intertwined and convoluted. The interconnection between the two activities is undeniable and often manifests in unusual ways. Academia searches for truth through knowledge gained primarily by research that is often spurred and aided by the accumulation of industry-generated data. Oil and gas exploration is a search for commercial hydrocarbons by the application of truth through both its proprietary research and by availing itself of the knowledge gained from academia. Both are invaluable assets to human knowledge and experience, and both would wither without the support, cooperation and access to the other's scientific contributions. An excellent example of these interactions is illustrated by the history of the search for commercial oil and gas in the Cretaceous rocks in the Rio Grande Rift in central New Mexico between 1952 and the present. An example of industries contribution to the geologic database is the present exploration effort on the Zia Pueblo where new valuable structural and stratigraphic information has added to the geologic history of New Mexico and to the understanding of the tectonics involved in the Rio Grande Rift in this area.

New Mexico Bureau of Geology's Fossil Fuel Information Resources and Outreach Programs

Douglas Bland[1] and Susan Welch[1]

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The New Mexico Bureau of Geology and Mineral Resources (bureau) is a division of the New Mexico Institute of Mining and Technology, and functions as the geological survey for the state. Since 1927 the bureau has been conducting research and providing information to scientists, educators, and the public regarding the state's geology, energy and mineral resources, and geohydrology through publications, maps, data collections, archives, outreach programs, and extensive website.The bureau's library contains thousands of technical publications, maps, open file reports, bulletins, circulars, memoirs, decision-makers field conference guidebooks**,** and issues of the quarterly periodical *New Mexico Geology*. The bureau's website (http://geoinfo.nmt.edu) contains vast amounts of data, information, publications, articles, features, and links. This information ranges from very technical geologic and natural resource data to more general material useful to New Mexico citizens and visitors curious about the geology and landscapes of our state. Data collections contain more than 20,000 boxes of New Mexico petroleum and mining core, cuttings from more than 15,000 wells, logs from 50,000 wells, plus production data, information databases, data analyses, and test records. The bureau's geologic and aquifer mapping programs have produced invaluable maps and data.Educating those outside of the fossil fuel industry about petroleum and coal is beneficial to all. The bureau produces two semi-annual, general interest, earth science publications. Fossil fuels are a recurring theme. The entire current issue of *Lite Geology* (April 2014), geared toward educators and students, is related to new technologies in the oil and gas industry. Past issues contain numerous petroleum and coal articles. Issues of *Earth Matters* contain articles such as: the bureau's analytical laboratories, NM's subsurface data library, NM's natural gas resources, hydrogeology, carbon sequestration, energy resources, coalbed methane, ongoing research at the bureau, and geologic mapping.The bureau has many other educational outreach efforts that relate to wide-ranging geologic topics, including fossil fuels. Rockin' Around New Mexico is an annual summer workshop that provides teachers with the scientific background to understand and teach about the geology and natural resources of New Mexico. Held in locations around the state, about 25-30 New Mexico K-12 teachers attend each year. We maintain an extensive mineral museum (14,000 visitors annually) where students enjoy hands-on lessons about connections between minerals and commonly used items. Each fall, bureau staff record radio spots on interesting geologic topics. They are broadcast on the public radio station KUNM during Earth Science Week, and scripts are posted on our website. In short, the Bureau of Geology has gathered materials and developed information used by the extractive industries and the public for over 85 years, which is currently available in multiple formats.

HYDROLOGIC MODELING OF THE WHITE SANDS DUNE FIELD, NEW MEXICO

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The shallow groundwater flow system of White Sands dune field, located within the Tularosa Basin of Southern New Mexico, likely stabilizes the base of the largest gypsum dune field in the world. The dune is saturated throughout nearly its entire accumulation thickness, resulting in a shallow water table (< 3 ft bgs) in the interdunal areas. Water table geometry and elevation play a critical role in controlling spatial extent of the dune field and accumulation thickness. The White Sands National Monument (WHSA) is concerned that lowering the water table may lead to increased scour and migration of the dune field, which could be unfavorable to the preservation of the flora and fauna that have adapted to survive there. In response to projected increases in groundwater pumping in the regional Tularosa Basin groundwater system, changes in surface water use, and the threat of climate change, the WHSA is interested in understanding how these changes on a regional scale may impact the shallow dune field aquifer.

We have collected hydrological, geochemical, and geophysical data in order to identify the water sources of that contribute to the dune field aquifer, and to assess interactions between the shallow aquifer with surface conditions and the basin-scale, regional system. Vertical hydraulic gradients in the unsaturated zone, temperature, and water quality data indicate that local precipitation is a source of recharge to the dune field aquifer. Additionally, geochemical and electrical resistivity data indicates a contribution of water from the regional Tularosa Basin groundwater system to the overlying saturated dune.

Mathematical modeling techniques are in use to characterize the relative importance of the sources of water to the dune filed aquifer, and to quantify the timescales on which changes may affect the shallow dune aquifer. A 1-dimensional, dune-scale model uses the seasonal temperature fluctuations as a tracer to estimate the upward flow of water from the regional to the saturated dune. We have also constructed a 2-dimensional, hydrologic model to attempt to characterize the regional groundwater flow regime near to the dune, as well as across the Tularosa Basin to a depth of 6 km. Computed and observed salinity and groundwater residence times are the primary means of model calibration. Preliminary results from the two mathematical models indicate the regional groundwater system does contribute flow to the dune aquifer. Both dune- and basin-scale models will improve the understanding of the interaction of the shallow dune aquifer with the deeper basin groundwater and surface conditions.

PALEOMAGNETIC, ANISOTROPY OF MAGNETIC SUSCEPTIBILITY, AND STRUCTURAL DATA BEARING ON MAGMA EMPLACEMENT AND THE GROWTH OF A MIOCENE, CINDER CONE.

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Recent studies on rifts zones suggest that cinder cones evolve through the growth of a complex magma plumbing systems. Due to their modest geometry, cinder cones have been commonly perceived to form by a single eruption from a single feeder dike. However, feeder dikes are rarely exposed and their remains are easily eroded. Understanding the fundamental system of how magma is redistributed in the Earth's crust and how cinder cone volcanoes evolve is difficult, as most outcrops are usually restricted to cliffs, ravines and anthropogenic sites. This research will study the complexity of volcanic substructures at the exposed roots of a cinder-spatter cone associated with the middle Miocene Jicin Volcanic field in the northeast Czech Republic. The approach of study is to prepare a detailed map of the Trosky Volcano based on a collection of structural and geophysical techniques to determine how the magma flowed through and from the volcano. Data from field (e.g. geologic mapping and macroscopic observation) and laboratory methods (petrography, paleomagnetism, anisotropy of magnetic susceptibility (AMS), and rock magnetic data) will provide new insights on the history of Trosky Volcano by determining the relative sequence of volcanic events. Field mapping of the area has revealed that there are many distinguishable volcanic features such as eruptive vents, numerous dikes, lava flows, Lava tubes, and volcanic bombs. Each of the volcanic features are unique and they offer indications of its eruptive past. The AMS directional data yields a magnetic fabric from sub-vertical to sub-horizontal with a sense of NE-SW to NW-SE. Most samples have a high susceptibility with an ellipsoid shape that is predominantly prolate. The majority of the samples yield a reverse polarity magnetization with one or two components of magnetization. The dominant magnetic mineral phases are hematite and pyrrhotite. The Trosky Volcano offers an exceptional opportunity to apply focused geophysical techniques to interpret the complex formation process of the internal magmatic plumbing system.

PRELIMINARY REPORT OF A NEARLY COMPLETE JUVENILE *PENTACERATOPS* FROM THE UPPER CRETACEOUS KIRTLAND FORMATION (HUNTER WASH MEMBER), SAN JUAN BASIN, NEW MEXICO

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The ceratopsid dinosaur *Pentaceratops sternbergi* is an index fossil of the Late Campanian Kirtlandian land-vertebrate "age" found almost exclusively in the Upper Cretaceous Kirtland Formation (Hunter Wash Member) of the San Juan Basin, New Mexico. A single record of a subadult *Pentaceratops* (San Diego Museum of Natural History 43470) is known from the Williams Fork Formation in northwestern Colorado but consists only of an incomplete and disarticulated skull. Here we preliminarily describe the most complete subadult *Pentaceratops* discovered to date (New Mexico Museum of Natural History P-68578). The specimen was found in the Hunter Wash Member of the Kirtland Formation in the Bisti/De-Na-Zin Wilderness Study Area during a 2011 paleontological survey funded by the Bureau of Land Management. It is partially articulated and consists of cranial elements and a nearly complete postcranial skeleton. We confidently assign NMMNH P-68578 to *Pentaceratops sternbergi* based on its diagnostic parietal and squamosals. Moreover, there is no evidence of any other ceratopsid in the Hunter Wash Member of the Kirtland Formation. The right and left squamosals are typical of *Pentaceratops* with subtriangular-shaped episquamosals fused along the outer margins. The median ramus of the parietal is slender with a U-shaped ior margin. Length measurements of the humerus (460 mm), ulna (405 mm) and femur (670 mm) suggest that this animal was just over half the size of a mature adult *Pentaceratops*. This is the most complete subadult specimen of *Pentaceratops*, thus it provides important insight into the ontogeny of the genus.

PALEOMAGNETIC AND ANISOTROPY OF MAGNETIC SUSCEPTIBILITY, STUDY OF THE BUENA VISTA DIKE, NORTH-CENTRAL NEW MEXICO

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The 5 km-long Buena Vista dike, intrudes the Cretaceous Benton Group and outcrops on the eastern side of the Sangre de Cristo Mountains near the transition between the Rocky Mountains and the Great Plains. At the northernmost outcrop, at least three compositionally distinct intrusions are exposed ranging from augite porphyritic basalt, quartz diorite and diorite. We hypothesize that the Buena Vista dike may be sourced from or genetically related to the Ocate Volcanic field. Rock magnetic, paleomagnetic, and anisotropy of magnetic susceptibility analyses are being conducted on core samples taken from 13 sites. Preliminary rock magnetic tests reveal that the primary magnetic phase is a cubic, Fe-Ti oxide phase of a restricted magnetic grain size. The Curie point temperature ranged from 480 to 540 degrees Celsius indicating that the samples contain a titanomagnetite phase with low to moderate Ti substitution. We see little contribution to the AMS fabric from paramagnetic phases and conclude that the AMS fabric is carried by a ferromagnetic phase of psuedosingle domain to a multi-domain grain size. AMS data indicate that most sites are oblate. The shape factor T values for the sites range from 0.209 to 0.903. Further work, including geochronology, paleomagnetism, and petrographic analyses, is aimed at determining the origin and time of emplacement of the Buena Vista dike and understanding Cenozoic magmatism east of the Rio Grande Rift.

THE HERMIT'S PEAK GRANITE: SYNKINEMATIC PLUTONISM AT 1.70 GA IN THE LAS VEGAS RANGE, NM

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The Hermit's Peak granite is a 1.70 Ga biotite-granite in the southern Sangre de Cristo Mountains of northern NM. It is located within a broad area that records both Yavapai and the later Mazatzal deformation, referred to as the Yavapai-Mazatzal transition zone. The goals of this study are to map mineral, textural, and structural variations throughout the Hermit's Peak granite in order to address its size and shape, how the granite was emplaced, and how it figures into the assembly of Proterozoic provinces. This tabular, northwest-trending pluton covers approximately 32 km^2 of the central Las Vegas Range. The composition of the Hermit's Peak granite varies slightly throughout, typically displaying euhedral to subhedral 1-2 mm sized grains and ranging from syenogranite to monzogranite. The granite intrudes Paleoproterozoic metamorphosed country rock at the western and northern most extents, with a moderate to strong foliation dipping, on average, to the SW and paralleling the strong foliations seen in the country rock. Along its eastern and southern exposures, the pluton is juxtaposed against Pennsylvanian aged sedimentary units along the Hermit's Peak thrust fault. Fabric development is defined by an alignment of biotite and is variable across the intrusion, but is generally strongest at the margins and weakest in the center. The foliation at the southwestern contact is defined by compositional bands that petrographic analysis reveals to contain primarily curvo-planar grain boundaries with some serrated quartz. An additional facies within 1.5 km of this contact displays serrated feldspar boundaries and ribboned quartz grains, paralleling a biotite foliation that developed in the transition between magmatic to submagmatic state. These data are most consistent with the synkinematic emplacement of the Hermits Peak granite.

USING THE LONGITUDINAL RIVER PROFILE OF THE RIO SAN JOSE AND $^{40}Ar/^{39}Ar$ DATING OF LATE-CENOZOIC BASALTS TO TEST MODELS FOR MANTLE-DRIVEN UPLIFT ACROSS THE JEMEZ LINEAMENT, NEW MEXICO

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Mantle-driven differential uplift has been proposed to contribute to dynamic typography in the western United States. Neogene and ongoing mantle flow is postulated to be driven by upper mantle convection and to cause subtle broad-scale differential uplift that affects surface topography. This study focuses on the possible connection between mantle convection and surface topography along the Jemez lineament in New Mexico, and is motivated by tomographic images from the EarthScope experiment that show this zone is underlain by low-velocity mantle that potentially could drive uplift.

To test this possible connection, we constructed a longitudinal profile of the Rio San Jose that crosses the lineament at high angles, and use dated elevated river terraces to construct paleoprofiles through time. Our rationale is that rivers are sensitive gauges of changing landscapes and differential uplift. $^{40}Ar/^{39}Ar$ dating of basalts that overlie river gravels at sixteen locations provides a method of evaluating denudation rates and tracking landscape evolution in this region.

The average long-term incision rate of the Rio San Jose has been ~105 m/Ma over the last ~4 Ma but the study found that the incision history of the Rio San Jose has varied significantly spatially as well as temporally. Incision rates of ~177 m/Ma are calculated from ~3.7 to ~2.6 Ma basalts with fast rates likely reflecting the construction of Mount Taylor. From ~2.6 to today, average incision rates have been ~77 m/Ma.

The modern longitudinal profile shows several features that deviate from an equilibrium concave–up shape. First, the profile has convex central reaches, including bowing of the 348 ± 5 ka Laguna Pueblo flow. Second, seismic and drill core data indicate the presence of a graben in the El Malpais valley with sediment fill of ~200 m in the downthrown block. Within this graben, a drilled well core with three buried basalt flows were sampled ranging from 20, 41, and 61 m depth, with the oldest flow yielding an age of 340 ± 90 ka. Third, the boundary zone between the Colorado Plateau and Rio Grande rift is characterized by a migrating knickpoint that shows differential incision rates from 0 to 217 m/Ma since eruption of the 198 ± 5 ka Suwanee flow. This flow preserves a paleo-knickpoint downstream of the modern one, suggesting upstream migration of a transient knickpoint at a rate of ~20 km/Ma.

We suggest that mantle-driven uplift along the Jemez lineament may explain these observations as follows: (1) the El Malpais valley graben parallels the Jemez lineament and intersects the Rio San Jose in its central, convex, reaches, and the graben is interpreted to indicate extension due to upwarping above the Jemez lineament, and (2) the differential incision along the Suwanee flow is a migrating knickpoint and may be a result of a combination of base-level fall and headwater uplift broadly associated with the mantle anomaly.

USING LASER-INDUCED BREAKDOWN SPECTROSCOPY AND CHEMOMETRIC ANALYSIS TO GENERATE A TOURMALINE PROVENANCE MODEL

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Laser-Induced Breakdown Spectroscopy (LIBS) and chemometric analyses can be used to determine tourmaline provenance and is preferable to electron microprobe analyses for three main reasons: (1) LIBS analysis is sensitive to light elements such as Li and H; (2) LIBS spectra include a large amount of information including useful matrix effects; and (3) LIBS analysis is rapid, inexpensive and field capable. Tourmaline provenance can be used to refine models of detrital mineral provenance because tourmaline crystallizes in a wide range of rock types over broad temperature and pressure ranges and acquires the trace element signature of its host rock during crystallization. In this study, tourmaline provenance will be assigned to six categories; (1) Li-rich pegmatites, (2) Li-poor pegmatites, (3) non-pegmatitic silicic igneous rocks, (4) pelitic mica schists, (5) calc-silicate rocks, and (6) hydrothermally altered rocks.

Tourmaline from a variety of localities around the world and within New Mexico were analyzed in an atmosphere of Ar using an Ocean Optics © 2500+ LIBS instrument with an Nd-YAG laser that emits light at 1064 nm. Principal Component Analysis (PCA) and Partial Least Squares Regression (PLSR) were used to determine the provenance of tourmaline by calibrating and validating the provenance model with tourmalines of known provenance. As expected, tourmalines from hydrothermal assemblages exhibit a wide range in composition. However, tourmalines from the other five lithologies form relatively tight groups in Principal Component space, and can be distinguished from each other using PLSR models.

CONCEPTS OF PETROLEUM EXPLORATION IN TODAY'S SHALE PLAY ENVIRONMENT

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Petroleum Exploration has moved from historical "Classic Hydrocarbon Traps" to " Shale Plays. In classic hydrocarbon traps, the petroleum has migrated out from the source rocks over a geologic time period and accumulated into traps that humans produce and use in human time scale. Shale plays go directly to the source rocks and extract the petroleum in a human time scale period by passing the geologic time scale accumulation step. This involves in essences mining the source rock shale's and producing with them with horizontal drilling and fracking to stimulate permeability.

To explore for source rock shale's, one can start with understanding the tectonic history and distribution of Oceanic Anoxic Events. Oceanic Anoxic Events are periods when the polar ice caps have melted and the natural deep oxygenating oceanic currents break down and as a result the deep ocean goes through a period of anoxia and becomes a reducing environment that sequesters carbon into the shale. Oceanic anoxic events can produce hydrocarbon source rocks when buried and heated to mature the petroleum products. Most of the major hydrocarbon producing source rocks in the world are generated by this process.

CRUSTAL ASSIMILATION DURING THE PETROGENESIS OF THE EL CALDERON FLOW, ZUNI BANDERA VOLCANIC FIELD, WEST-CENTRAL NEW MEXICO

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Whole rocks and phenocrysts from the 33.4 ka El Calderon basalt flow of the Zuni-Bandera volcanic field in west central New Mexico are used to distinguish between melting of heterogeneous mantle sources and mixing of a single asthenospheric magma with variable amounts of felsic crust during ascent. The Zuni-Bandera volcanic field is located along the Jemez lineament, an 800km long suture zone that is defined by a series of young volcanic field stretching from Springerville, Arizona, to Raton, New Mexico. El Calderon basalts have OIB like trace element signatures, and whole rock Sr isotopes show little variation, ranging from 0.70472±7 to 0.70479±10 (Peters et al., 2007).

While whole rock major element variations require only ~2% fractionation of olivine, trace element enrichments suggest a reduction in magma volume of up to 40%. Whole rock trace element results discount fractionation as the only process affecting the El Calderon magma and are consistent with mixing of two compositional end member magmas. Variations of major elements of melt inclusions correspond with crystal fractionation of olivine, while trace element variations are consistent with two-component mixing.

References:

- Peters, T.J., Menzies, M., Thirlwall, M., Kyle, P.R., 2008, Zuni-Bandera volcanism, Rio Grande, USA – Melt formation in garnet- and spinel - facies mantle straddling the asthenosphere - lithosphere boundry. Lithos 102, p. 295-315.

FIELD PLAY AND THE NEW MEXICO GEOLOGICAL SOCIETY FALL FIELD CONFERENCE: INCORPORATING AUGMENTED REALITY GEOLOGIC FIELD TRIPS AND LOCATION-SENSITIVE EDUCATIONAL LESSONS FOR A PERSONALIZED, INTERACTIVE GEOSCIENCE EXPERIENCE

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Field Play is an augmented reality educational and experiential tool for the geosciences built to run on Android-based mobile devices. Free and easy to use, Field Play enriches learning on many levels as users are able to customize the breadth and depth of content to accommodate their interest and experience levels ranging from K-12 through college level students, the general public, or professional geoscientists. The goal of the Field Play application is to promote scientific education in a way that is personal, interesting, relevant, and accessible.

The Field Play system is based around augmented reality geologic field trips that overlay educational data with the physical world. The New Mexico Geological Society (NMGS) will incorporate Field Play into its Fall Field Conference (FFC) by adding a downloadable augmented field trip and associated content to its traditional guidebook format. While at the FFC, users can explore their location relative to the predetermined route as well as geologic features, terrain, and active content using the embedded GPS unit in their mobile device. When a user enters an area of active content as part of the NMGS FFC, they are guided through the field trip via audio tour. At FFC stops, users are given the opportunity to explore interactive submodules, including augmented reality binoculars, informational text, topographic and geologic maps, and short video (YouTube) lessons. The Field Play YouTube channel offers educational videos in 5-10 minute segments discussing key locations, terminology, and concepts. These educational videos incorporate interviews by topical experts, animations, photographs, and video, allowing the user to expand their knowledge on related topics.

Content from the 2014 NMGS FFC can also be accessed from home when not in an area of active content via web browser; thus, trips and content can be re-visited by users via internet or upon returning to field locations any time after download. Field Play virtual field trip content can be accessed and searched (e.g., by regional location or topic of interest) online or on a mobile device, and content can be combined by users to create their own personal trip, providing a useful for both informal and formal geoscience education.

EXAMINING INDUCED SEISMICITY IN SE NEW MEXICO IN THE VICINITY OF THE WASTE ISOLATION PILOT PLANT

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Induced seismicity is a human generated phenomenon that causes a release of seismic stress in the crust through human activities such as surface and underground mining, impoundment of reservoirs, withdrawal of fluids and gas from the subsurface, and injection of fluids into underground cavities. The New Mexico section of the Permian basin is in an active area of oil and gas production. The region is also the home of the Waste Isolation Pilot Plant (WIPP), a geologic repository for radioactive waste, located just east of Carlsbad, NM, close to the region of active industry activity. Small magnitude earthquakes have been recognized in the area for many years, recorded by a network of short period vertical component seismometers operated by New Mexico Tech. However, for robust comparisons between the seismicity patterns and the injection well locations and rates, improved locations and a more complete catalog over time are necessary. Here we present a revised catalog of earthquakes in this area, with improved locations resulting from the addition of data from the 3-component broadband EarthScope Flexible Array SIEDCAR experiment that operated in the area between 2008-2011. Known events are relocated with the additional phase picks from the SIEDCAR stations and compared with the injection well locations. We also use the known events as templates for a waveform scanning effort to identify additional events that occurred within the time period. This more complete seismicity catalog is then compared with the available monthly injection rates during this time period.

HYDROGEOCHEMICAL ANALYSIS OF A DESERT SPRING ECOSYSTEM TO DETERMINE BOUNDARY CONDITIONS FOR A PROPOSED ENDANGERED FISH, ZUNI BLUEHEAD SUCKER, ZUNI MOUNTAINS, NEW MEXICO.

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The semi-arid landscape of the southwest has been home to desert fishes for over 10,000 years. Throughout this time, the fish have evolved in isolated niches during dry years and have mixed with high waters during wet years. Today, due to land use practices and climate change, 20% of the native desert fish species are extinct. Many more are listed as endangered (54) or proposed to be endangered (124), including the Zuni Bluehead Sucker (ZBS). Once abundant in the Little Colorado River, the ZBS is now reduced to three spring-fed sections of 2nd and 1st order tributaries of the Zuni River in the Zuni Mountains, New Mexico. My research focuses on one of the habitats for the ZBS, Agua Remora, an intermittent stream with headwaters located in the uplifted granite block. A perennial hillslope spring flows into the channel some 2 km west of the continental divide. At the spring site, several man-made pools are found. Where the spring water flows into the channel and below, fish are present. Above the spring input, ZBS are have not survived. This research used spatial and temporal hydrogeochemical data to determine suitable habitat conditions for the species at the Agua Remora site. These data will be used to better inform resource managers about the fish habitat and to ensure survival of the species.Beginning in May 2012, three sample sites were determined for the collection of water samples and continuous monitoring. These sites included; 1. The spring (Spring) which is 15 meters away from the channel on a hillslope, and 2. A perennial pool in the channel above the spring input where ZBS are not found (Fishless) and 3. A perennial pool in the channel below the spring where ZBS (Fish) have been found there since 2004. Methods for the sites included seasonal field visits for ion and isotope analysis as well as continuous monitoring of physicochemical parameters including water temperature, specific conductance and dissolved oxygen.Analysis of major ions, indicate that the spring waters and the stream waters represent different hydrochemical facies, $NaClSO_4$ and $CaMgHCO_3^-$ respectively, indicating they have different flow paths. Isotopic analysis shows elevated δD and $\delta^{18}O$ values indicating different recharge pathways for the channel water and the spring water. Continuous monitoring of parameters suggests that the Fishless pool is anoxic after antecedent precipitation events with dissolved oxygen (DO) values < 2 mg/l for more than 30 days. In comparison, the DO values in the Fish pool averaged 6 mg/l and rebounded after wetting events. Spring waters have DO ranging between 1-4 mg/l. These data suggest that the spring input is providing the necessary discharge conditions for re-aeration during low flow. The spring water also lowers the residence time in the Fish pool making the habitat more suitable for ZBS after infrequent precipitation events.

DISTRIBUTION, TRANSPORT, AND ACCUMULATION OF PYROGENIC BLACK CARBON IN POST-WILDFIRE WATERSHEDS

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Post-wildfire debris flows and flooding deliver high loads of sediment and pyrogenic black carbon (PyC) to downstream waterways. Generated by incomplete combustion of organic matter, PyC in the form of soot and char is transported and re-deposited throughout the watershed. Due to the effects of PyC on water quality, its potential to sequester contaminants and its role in storing carbon over short and long timescales, the accumulation of PyC is a multi-faceted and dynamic issue for ecosystems and human populations. The impacts of two recent wildfires in Northern New Mexico are studied with the goal of understanding the fluxes and residence times of PyC in post-wildfire, semi-arid mountainous watersheds. Employing burn severity maps and geospatial data, three sites were selected to collect soil and water samples to characterize PyC: a control, an area impacted by the 2011 burn, and an area impacted by the 2013 burn. In this study, PyC is treated as both a particulate that is transported throughout the watershed, and as a solute that is dissolved and degraded in surface and groundwater. Two black carbon quantification methods are employed: The chemo-thermal oxidation (CTO-375) method to distinguish between soot and char, and the benzene polycarboxylic acids (BPCA) method to quantify the total concentrations of PyC throughout the watershed and to compare concentrations between different geomorphic features and between control and burn sites. Preliminary data from the CTO-375 method shows comparable soot concentrations in the control, 2011, and 2013 burn indicating that the soot is more recalcitrant than char and remains in the watershed long after a wildfire. This data also suggests that the fluxes of black carbon over short time scales are composed mainly of char.

^{40}Ar/^{39}Ar Muscovite Thermochronology and Monazite Geochronology of New Mexico Pegmatites

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^{40}Ar/^{39}Ar muscovite dates from mainly pegmatites from the Tusas, Sandia and Manzano Mts provide cooling ages between about 1450 and 1330 Ma and in general record diachronous cooling across the region. Samples from the Petaca District pegmatites in the Tusas Mts have comparatively young muscovite ages between 1406 and 1328 Ma whereas data from the Sandia and Manzano Mts are generally older than 1400 Ma and have steps in their age spectra that approach igneous intrusion ages between 1440 and 1460 Ma. Our initial goal of directly dating the Petaca District pegmatites using muscovite argon data was not successful due to high (>500°C) ambient country rock temperatures related to 1.47 to 1.40 Ga metamorphism. The data do however constrain cooling of the basement to about 375°C between 1.4 and 1.35 Ma. The pegmatite muscovites from 36 samples have overall flat age spectra with integrated ages between 1406 and 1328 Ma and broadly group at 1400, 1380, 1360 and 1335 Ma. The finer grained host rock muscovites from six samples have integrated dates ranging 1363 to 1334 Ma. Preliminary electron microprobe monazite U+Th/Pb ages from the Globe and Meadow pegmatite yield ages at ~1430 Ma, confirming that argon muscovite ages are not pegmatite emplacement ages. Muscovite argon ages in the Sandia and Manzano Mts can approximate intrusion ages based on concordance with published U/Pb zircon ages from the Sandia and Priest plutons. The near concordance between argon and U/Pb ages indicates a higher level of crustal exposure in central New Mexico compared to northern New Mexico. State wide compilation of argon data show a strong occurrence of muscovite ages at ~1450-1470 Ma which compares well with the onset of "1.4 Ga" metamorphism recorded by published Lu/Hf garnet ages from the Tusas Mts.

Efforts to quantitatively extract thermal histories from the muscovites using laboratory derived diffusion coefficients based on the fraction of ^{39}Ar released seems to have mixed success. Despite long step-heating experiments to maximize the likelihood of muscovite stability during heating, coarse-grained samples appear to catastrophically dehydroxilate resulting is perhaps inaccurate diffusion coefficients. In contrast, finer grained samples appear to yield sensible age spectra and diffusion coefficients. A sample from the Bosque Peak area yields an age gradient from about 800 to 1500 Ma and thermal history inversion indicates nearly isothermal conditions at ~325°C between 1500 and 1400 Ma or cooling below at least 200°C at 1500 Ma followed by reheating to ~350°C at ~1400 Ma. This technique holds promise to provide the first quantitative thermal history measurements for the time period between 1.6 and 1.4 Ga.

In situ laser ablation ^{40}Ar/^{39}Ar ages of muscovites yield variable apparent ages and generally reveal younger ages near crystal edges and old uniform ages for crystal interiors. This spatial relationship indicates that the physical crystal size is defining the argon diffusion dimension.

RADIOGENIC ISOTOPE STUDIES OF ZIRCON FROM PROTEROZOIC ROCKS IN NORTHERN NEW MEXICO AND IMPLICATIONS FOR DEFINING PRECAMBRIAN PROVINCES

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Crustal growth along the southern margin of Laurentia is typically viewed in three major stages: the 1.7 Ga Yavapai orogeny, the 1.65 Mazatzal orogeny, and intracratonic deformation and magmatism at 1.45 Ga. Historically, the Jemez lineament has been viewed as the potential suture zone between the Yavapai and Mazatzal provinces. New data indicates that this feature is not entirely consistent with a boundary of this nature, and may be more accurately described as a backarc transition zone between the provinces. Support of this are metasedimentary successions consisting of only Yavapai-aged detritus on either side of the Clear Creek shear zone—an expression of the lineament in the northern Sierra Nacimiento Mountains—constrained by 1.7 Ga intrusions into the sediment.

The relationship between these basins, intrusions, and growth along southern Laurentia present a complex process involving rapid erosion of granitic rocks into basins producing first cycle, ultramature quartzite successions, and rapid basin submergence to allow pluton emplacement as early as 1698 Ma. The characteristics of these metasediments, in composition and detrital zircon age, allow their inclusion in similar quartzite basins along the southern margin of Laurentia. The complexity of the relationships between rock units spanning the Nacimiento uplift makes interpretation of the transition from the Yavapai province to the Mazatzal province ambiguous, raising questions about the nature of this boundary. Considering this, we will continue to examine tectonic and stratigraphic relationships between rock units in the Sierra Nacimiento Mountains and similar successions in the Picuris Mountains, while analyzing Hf-Yb-Lu isotopic character of plutons in the Nacimientos in an attempt to understand crustal origin and evolution across the Yavapai-Mazatzal boundary. This study will allow us to further define the nature of this provincial transition and Proterozoic continental evolution in southwestern Laurentia.

References:

- Jones, J.V., III, Connelly, J.N., Karlstrom, K.E., Williams, M.L., Doe, M.F., 2009, Age, provenance, and tectonic setting of Paleoproterozoic quartzite successions in the southwestern United States, GSA Bulletin, January/February 2009, vol. 121, p. 247-264.
- Jones, J.V., III, Daniel, C.G., Frei, D., Thrane, K., 2011, Revised regional correlations and tectonic implications of Paleoproterozoic and Mesoproterozoic metasedimentary rocks in northern New Mexico, USA: New findings from detrital zircon studies of the Hondo Group, Vadito Group, and Marqueñas Formation, GSA Geosphere, August 2011, vol. 7, no. 4, p. 974-991.
- Karlstrom, K.E., Amato, J.M., Williams, M.L., Heizler, M., Shaw, C.A., Read, A.S., Bauer, P., 2004, Proterozoic Tectonic Evolution of the New Mexico Region: A Synthesis, The Geology of New Mexico, A Geologic History, New Mexico Geological Society, p. 1-34.
- Magnani, M.B., Miller, K.C., Levander, A., Karlstrom, K.E., 2004, The Yavapai-Mazatzal boundary: A long-lived tectonic element in the lithosphere of southwestern North America, GSA Bulletin, September/October 2004, vol. 116, no. 7/8, p. 1137-1142.
- Premo, W.R., Kellogg, K.S., Budahn, J., in review, U-Pb Zircon Geochronology, Major and Trace Element Geochemisty, and ND Isotopes on Proterozoic Rocks in the Sierra Nacimiento Region, North-Central New Mexico—Are These Rocks the Leading Edge of the Mazatzal Arc? U.S. Geological Society Professional Paper, in review.

FLUORIDE LEVELS AT PORTALES, BLACKWATER DRAW AND OASIS STATE PARK

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Fluoride is a naturally occurring element in water, contributed from surrounding geological formations. Portales and surrounding water supplies are drawn from an ancient aquifer where the water has been housed for a long time. Ionic exchange between the water and surrounding rocks has resulted in high levels of fluoride. Portales and surrounding area water supplies have tested close to the U.S. EPA standards for 4 ppm for fluoride. Portales Water Suppliers issue an annual drinking water quality report, listing high fluoride levels as an area of concern. Fluoride is beneficial to bone growth in small amounts (up to 1 ppm). In higher concentrations, mottling of teeth may appear in young children, which is the *first manifestation* of dental fluorosis. Long term exposure to fluoride may result in skeletal fluorosis, extreme cases resulting in painful bone deformities, and eventual death. Fluoride affects bones, soft tissue, and vital organs.Water samples were taken from each of the sites in order to verify concentration levels. Fluoride concentrations were measured using the EPA-approved method of ion selective electrode electrochemistry. All sites tested indicate levels of fluoride that are near EPA Primary Standard levels. All surpass EPA Secondary Standards. Oasis State Park Lake came in at almost *twice* the concentration levels of the other test sites as the result of ion evaporative concentration.In order to determine the source of contamination, many factors must be considered. There are 3 layers of volcanic ash that were deposited from active volcanos during the early history of New Mexico. The Gueje pumice, the Cerro Toledo tephra or the Tsankawi pumice may contribute fluoride. Climate change can affect weather patterns, bringing periods of scant rainfall, causing the buildup of toxins in soil. These toxins remain until they are washed away by precipitation. Clay soils may contribute fluoride as a result of capillary action. Portales has an agricultural based economy, so agricultural fertilizer runoff may contribute to the problem. All of these factors work together to cause the high concentrations of fluoride found in our water.

References:

- Kundu, N, et. al., Geochemical appraisal of fluoride contamination of groundwater in the Nayagarh District of Orissa, India*, Environmental Geology*, 41:451-460. Portales Water System Drinking Water Quality Report for 2011.Lucas, S G, Ulmer-Scholle, D S, 2001, Geology of the LLano Estacado, *NMGS 52nd Annual Field Guidebook.*Basic Information About Fluoride in Drinking Water, EPA, http://water.epa.gov/drink/contaminant/basic/information/fluoride.cfm

THE NAASHOIBITO IS LATEST CRETACEOUS

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A rich mammal, dinosaur and plant fossil record is contained within the Cretaceous and Paleocene rocks of the San Juan Basin (SJB) in NM. Details of this record have been hampered by lack of adequate geochronology that has also lead to highly contested conclusions about the dinosaur record. Direct dating of sedimentary rocks using a key volcanic ash near the base of the Nacimiento Formation and utilizing detrital sanidine dating from the Naashoibito Member of the Kirtland Formation, the Nacimiento Formation and the Ojo Alamo Sandstone is providing much needed radiometric control on the chronostratigraphy. The ash near the base of the Nacimiento yields concordant U/Pb zircon and $^{40}Ar/^{39}Ar$ sanidine dates and confirms that it is early Paleocene and within magnetochron 29n. Detrital sanidine dating of the Naashoibito reveals that it is not older than latest Cretaceous and provides a key result to constrain the paleomagnetic data. Coupling the ash date, the detrital sanidine data and a composite paleomagnetic record demonstrates that the Naashoibito (i.e., the dinosaur fossil bearing sediments of the Ojo Alamo Sandstone) is not younger than latest Cretaceous and thus does not support Paleocene dinosaurs.

Detrital sanidine dating of the Ojo Alamo Sandstone (*senus stricto*) near Mesa de Cuba reveals a single date that is early Paleocene seemingly providing the first radiometric constraint that at least part of the Ojo Alamo is Paleocene. We caution that a single grain is not ideal, however the date is in agreement with other Paleocene indicators. Detrital sanidine dates within the Nacimiento at Mesa de Cuba always contain a population of Paleocene grains suggesting that this method can provide ages at or near the depositional age of the rocks. Additionally the data suggests that the base of the Nacimiento is not time transgressive.

The data and conclusions from the SJB are not possible without ultra high precision Ar/Ar geochronology obtained on the new ARGUS VI multi-collector mass spectrometers housed at the New Mexico Geochronology Research Laboratory. These instruments can now provide data that will greatly expand the ability of the argon dating method and can also provide the precision necessary to answer important questions regarding mass extinctions and evolution rates. We seek to fully intercalibrate methods of geochronology, paleomagnetism and astronomical tuning at unprecedented levels of precision, and eventually, accuracy.

REPEAT LIDAR AS A TOOL FOR INVESTIGATING GEOMORPHIC CHANGE IN A WATERSHED: A CASE STUDY OF CATASTROPHIC EROSION IN FRIJOLES CANYON, BANDELIER NATIONAL MONUMENT, NEW MEXICO, USA

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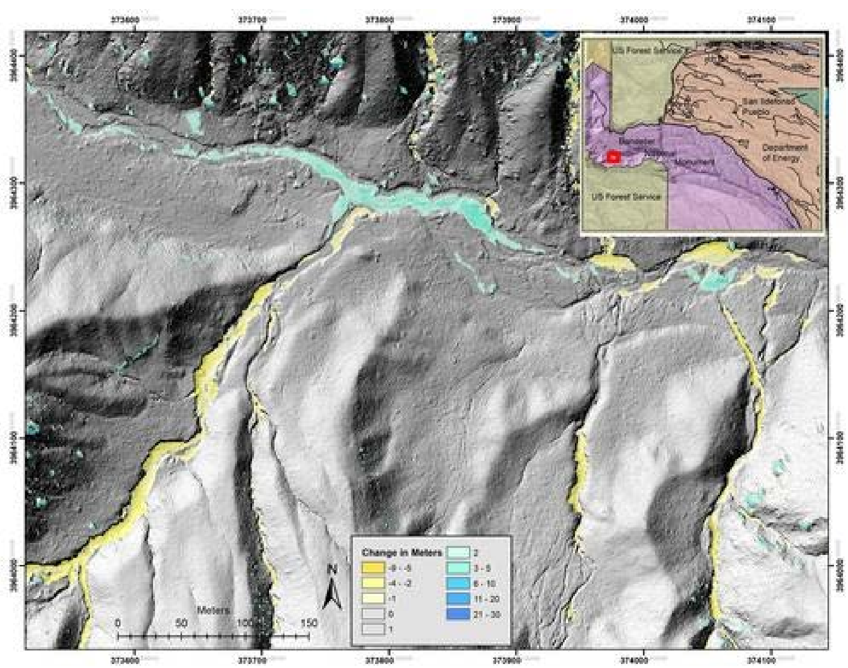
Repeat aerial LiDAR imagery was acquired for the Frijoles Canyon watershed (~17.5 mi^2) located within Bandelier National Monument in May 2010 and again in September 2013. This sequence captured landscape-scale changes that occurred as a result of the July 2011 Las Conchas wildfire which severely burned a majority of the upper watershed and left the area vulnerable to post-fire flooding. The largest flood occurred in response to an unprecedented multi-day precipitation event totaling ~8-inches (approximately one third of the annual rainfall), which generated a peak flow of ~9500-cfs on September 13, 2013. Numerous smaller rain events have also generated large magnitude runoff including a ~7000-cfs flood in August 2011 and a ~6000-cfs flood in July 2013. Erosional impacts include landslides, debris flows, scour of the main stem and tributaries, undercutting of canyon walls, development of rills on side slopes, and widening of the channel. Changes in drainage density, ruggedness, and gradient record the effect of reduced vegetative cover and elevated storm intensities on drainage morphology. Subtraction of the 2010 LiDAR grid from the 2013 LiDAR grid provides quantitative values for regions of scour and aggradation. Hydrographs, repeat photos, and footage of fire and floods complement the LiDAR imagery as a record of this sequence of catastrophic change.



REASONABLE FORESEEABLE DEVELOPMENT OF THE MANCOS SHALE IN THE SAN JUAN BASIN, NEW MEXICO

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Here, we summarize progress in our assessment of the impact of unconventional oil and gas development in the Mancos Shale on groundwater supply sustainability in the San Juan Basin (SJB). The measurement of actual water use in the SJB is a formidable task, so we tackle this tough problem using three indirect approaches. First, we evaluate the amount of groundwater that could be used in the basin by tabulating the water rights that have been allocated to a variety of stakeholders by the Office of the State Engineer. The largest allocations in the SJB are assigned to domestic users and municipalities (28.2%), mining (coal and uranium, 31.1 %), and food production (24.7%). The petroleum industry owns 6.3% of the groundwater rights, totalling ca. 6674 acre-feet/year (afy). Second, using data from the Oil Conservation Division and FracFocus.org, we tracked the amount of water reportedly used in hydraulic fracturing of both vertical and horizontal oil and gas wells since 2005. Vertical wells drilled into the Mesaverde, Dakota, and Mancos/Gallup account for approximately 75% of hydraulically fractured completions since 2005. Mesaverde vertical wells averaged 150,000 gals/well (0.46 af), Mancos/Gallup vertical wells averaged 125,000 gals/well (0.38 af) and Dakota vertical wells used 105,000 gals/well (0.33 af). The water usage for horizontal Mancos/Gallup wells in the SJB averages 3.0 af/well. This average derived from data for 46 of the 51 (90%) producing horizontal wells as of November, 2013. Operators in the SJB are using produced water and nitrogen foam as a means to reduce water use. Third, we are using the formation top data from scout cards and well logs to create isopach maps of the eleven major aquifers in the San Juan Basin. The volume of groundwater in storage in each aquifer is estimated from the isopach maps using GIS software and stochastic analysis of hydraulic properties. We begin by calculating the volume of material between formation tops, then estimate volume of fluids in the pore spaces and the amount of fluid retrievable, and finally estimate the amount of potable (< 1000 mg/L TDS) versus brackish water. The complex stratigraphy of the San Juan Basin caused by multiple northeast-southwest transgressions and regressions of a northwest-trending, irregular shoreline across the area complicates these calculations. Complications include discontinuity of units, mixtures of rock types, variable porosity and permeability laterally and with depth, the presence of oil and gas in pores, and the presence of natural fractures.

EOCENE TURTLES FROM THE SAN JOSE FORMATION, SAN JUAN BASIN, NEW MEXICO

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E. D. Cope described the first Early Eocene turtles from the San Juan Basin during the 1870s. Hay (1908) subsequently (and last) reviewed these turtles, assigning them to 15 species in seven genera and five families. However, many of these species are based on nondiagnostic, fragmentary material and thus are nomina dubia. For example, we identify “Kallistra costalata” as a nomen dubium because its type material consists of fragments of two other species. Further, Platypeltis seralis is a nomen dubium because its type specimen has been missing since before the work of Hay (1908). We have revised the alpha taxonomy of the San Jose Formation turtles to conclude that there are six genera and six valid species of fossil turtles, all from the Regina Member “Almagre local fauna.” These include Baena arenosa and Hadrianus majuscules, because we return the species Geochelone (Manouria) majuscule to the genus Hadrianus and to its former specific epithet. We do not believe there is sufficient reason to combine Hadrianus and Geochelone (Manouria) given the enormous ghost lineage this creates for the genus. Further, Echmatemys lativertebralis and E. cibolensis are combined into E. septaria on the basis of non-diagnostic types lacking sufficient differences from the type of the genus to justify their separation as new species. This means that there are no longer any emydid turtle species known only from the San Jose Formation, as this species is also known from the Bridger Group in Wyoming. All San Jose Formation trionychid specimens lack diagnostic types and are referred to Plastomenus sp. These species were defined largely on their shell ornamentation, which is not diagnostic, as it can vary greatly within a species. Collections that post-date the work of Hay include fragments attributable to Baptemys garmani and Planetochelys ditheros. The matching bosses of the carapace and plastron make Planetochelys distinct and easily recognized. We believe that some specimens in the New Mexico Museum of Natural History and Science Collection are Planetochelys ditheros because they do not appear to be from a large enough turtle to represent another known species of Planetochelys. Comparison to broadly coeval turtle assemblages in Wyoming indicates that the San Jose turtle assemblage coincides to approximately the Lysitean sub-land-mammal “age,” (middle Wasatachian), in agreement with the previously assessed age based on mammalian fossils.

References:

- Hay, O. P., 1908, The fossil turtles of North America: Carnegie Institute of Washington Publication, 75,

NEW RECONSTRUCTION OF THE LATE TRIASSIC AETOSAUR RIOARRIBASUCHUS CHAMENSIS FROM THE SNYDER QUARRY, CHAMA BASIN, NORTH-CENTRAL NEW MEXICO, USA

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Based on newly prepared material from the Upper Triassic (Revueltian) Snyder Quarry in north-central New Mexico in the collection of the New Mexico Museum of Natural History (NMMNH) we attempt to model the shape of the carapace of Rioarribasuchus chamensis. We believe this animal was approximately 640 mm wide at its broadest point. The well preserved left medial plate (NMMNH P-33820) used in this reconstruction is approximately 1.2 times the length and 1.55 times the width of that of the largest scute of the previous reconstruction of Desmatosuchus haplocerus (Long and Murry, 1995, NMMNH C-2433). The Desmatosuchus reconstruction is approximately 330 cm long; multiplying this by the ratio of the lengths of Rioarrabasuchus scutes to those of Desmatosuchus we estimate approximately 390 cm for the length of R. chamensis. As a result we conclude that Rioarribasuchus was a substantially larger and thicker bodied animal than its relative Desmatosuchus. By comparison with D. haplocerus we infer that R. chamensis had approximately 23 rows of dermal armor between the end of the cervical plates and the beginning of the caudal plates. The collection of the NMMNH contains parts of seven rows totaling nine medial plates. This leads to the conclusion that many of the medial plates of R. chamensis remain unknown. We would expect an equivalent number of lateral plates, but at this point we only have six of R. chamensis in the NMMNH collection. Also of note is the fact that no large shoulder spikes have been found at the Snyder Quarry other than one fragmentary spike only 9 cm long with an estimated 2 cm missing at the tip. Conversely, Desmatosuchus spikes measures up to 22.5 cm in NMMNH C-2433. A previous reconstruction of the carapace of R. chamaensis was attempted by Parker (2007) but shows several questionable features; the most visible of these is the forward facing spikes on the medial plates. These should be facing caudally based on the imbrication of the medial plates. This change moves the spikes on these plates to the outside edge of the carapace rather than along the midline. Further, several of the plates referred to in Parker (2007) as anterior caudal lateral plates display signs of imbrication and widening that would place them in the cervical region of the carapace. Another issue is the line of dorsal spines running the length of the tail. We see no evidence of this in the fossils in the NMMNH collection.

References:

- Long, R. A. and Murry, P. A., 1995, Late Triassic (Carnian and Norian) tetrapods from the southwestern United States: New Mexico Museum of Natural History and Science, Bulletin 4, 91 p.
- Parker, W. G., 2007, Reassessment of the aetosaur 'Desmatosuchus' chamaensis with a reanalysis of the phylogeny of the Aetosauria (Archosauria: Pseudosuchia): Journal of Systematic Paleontology, v.e 5, p. 41-68

NEW U-PB ZIRCON GEOCHRONOLOGY DATA SUPPORTING 1.7 GA CRYSTALLIZATION AGE FOR THE HERMIT'S PEAK GRANITE, LAS VEGAS RANGE, NEW MEXICO

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Numerous Proterozoic granitoid plutons are exposed in the Las Vegas Range, the most prominent of which is the Hermit's Peak granite (HPG). The HPG is a tabular body that intrudes basement quartzofeldspathic gneisses and amphibolites >1.70 Ga. The body is truncated on the east by the Laramide-age Hermit's Peak thrust fault, which juxtaposes Proterozoic basement against Paleozoic strata to the east. The HPG has often been categorized as a 1.4 Ga pluton and considered part of the enigmatic trans-Laurentian Mesoproterozoic rhyolite-granite magmatic event. The HPG displays a fairly regular steeply dipping N-NW trending biotite foliation and abundant synplutonic pegmatite sills. In thin section, the biotite occurs as euhedral plates, quartz shows straight to undulose extinction, quartz-feldspar boundaries range from curviplanar to moderately interdigitate, and feldspars show recrystallized margins. The HPG foliation is strongly developed and parallel to that of the amphibolitic country rock at its western and southwestern contacts. While no contact relationship was observed to the east, the fabric intensifies to an ultramylonite defined by a very fine grain size, ribboned feldspar and quartz, and gneissic banding before being truncated by the Hermit's Peak thrust fault. The elongate pluton shape, the parallelism between granite and amphibolite foliations, and the continuum between magmatic and high-temperature solid-state processes during the development of the granite foliation are strong evidence for the syntectonic emplacement of the Hermit's Peak granite. Four samples from the Hermit's Peak batholith showing variable degrees of fabric development yielded U-Pb zircon crystallization ages of 1.714±0.017 Ga (n=19), 1.705±0.017 Ga (n=24), 1.700±0.012 Ga (n=25), and 1681±0.023 Ga (n=22). Thus, the HPG belongs to the suite of ca. 1.7 Ga plutons intruded during Proterozoic province assembly.

View of northwestern face of Hermit's Peak from Johnson Mesa.

TWENTIETH-CENTURY FLOODS DOWN ABO ARROYO, REVEALED BY COAL-CLAST AND CLINKER DEPOSITS AND HISTORIC PHOTOGRAPHS, SHOW STREAM BEHAVIOR DIFFERENT FROM OTHER ARROYOS IN THE REGION

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Widely scattered coal and clinker clasts and flotsam, combined with historical photos, and modern observations in ungaged Abo Arroyo indicate valley-wide flooding and significant changes in sediment transport and erosion during the 20th century. Coal and clinker granules and pebbles (2-40 mm diameter) and flotsam of whole juniper trees and other wooden debris along the valley floor of Abo Arroyo show that the valley was inundated by a large flood or floods sometime between 1911 and 1935. The coal must have come from spills along the ATSF railroad through Abo Pass to the east, a route that was completed in 1911 and had a number of wrecks of coal-powered steam trains transporting coal. Abo Arroyo drains westward from Mountainair, NM, to the Rio Grande. West of Abo Canyon its valley shows only a minor increase in contributing area for 25 km, and it is a hydrologically losing stream. Between 1911 and 1935, the most likely period for extensive flooding was in August and September of 1929, when regional storms and flooding occurred on the Rio Puerco, Rio Grande, and other gaged tributaries. Aerial photographs taken in 1935 show that the lower 20 km of Abo valley had anastomosing unincised channels, gravel bars, and slackwater yazoos along the valley margins that spread coal clasts across the entire valley. Aerial photographs taken in 1947 show that much of the coal had been remobilized, reworked, and partially buried by later flood deposits. The lowest reach of Abo Arroyo became entrenched by 1954. Once the arroyo was incised about 4 m, eolian processes on the valley floor created sheet sands and coppice dunes that buried most of the coal. Harvester ants between the dunes tend to collect granules of coal and clinker in their hills, while blow-outs and small mammal burrows expose larger clasts of coal and clinker.

The active depositional facies on the floor of the lower Abo valley after the coal floods and present exposures along the incised arroyo contrast with other streams in adjacent semiarid drainage basins. First, lower reaches remained unincised as recently as 1947 rather than being incised in the 19th century. Second, due to concentration of stream power, the arroyo extended incision downstream through time rather than by the common model of arroyo headwall cutting and migration upstream (except for the lowest 1-km reach). Of note, the gradient of Abo Arroyo is 0.0074, nearly three times steeper than that of the Rio Puerco (on the other side of the Albuquerque Basin) and seven times steeper than the Rio Grande. Third, although the alluvium of the valley floor is predominantly bedded sand, silt, and clay, the modern channel consists primarily of subangular to subrounded boulders and cobbles with temporary deposits of sand, silt, and clay on bars and pools left under waning flow. Fourth, grass is the predominant vegetation along this semiarid drainage--the modern channel and point bars have few large shrubs such as fourwing salt bush or tamarisk.

PENNSYLVANIAN XIPHOSURID FOSSILS, BEEMAN FORMATION, OTERO COUNTY, NEW MEXICO

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We document two body fossils of the xiphosurid (horseshoe crab) *Euproops danae* Meek and Worthen from lacustrine black shale of the Missourian interval of the Beeman Formation near Alamogordo, New Mexico. These specimens, although incomplete (they only preserve the opisthosoma), show diagnostic features that justify assignment to *E. danae*, including a median tubercle on the third ring of the axial column, a tubercle on the ior lobe of the axial column and pleural ridges that end in marginal spines. This is the first report of *E. danae* from the western USA and the first documentation of xiphosurid body fossils in the Pennsylvanian of New Mexico. *Euproops danae* is a characteristic Carboniferous coal swamp form that is usually associated with freshwater habitats. The paleoecology of the site that yielded the xiphosurid fossils is most likely a freshwater lake deposit. The shale and siltstone layers from which the xiphosurid fossils are derived comprise a 10-meter thick coarsening upward sequence. At the base, a dark, organic-rich shale rests directly on medium-grained, ripple laminated sandstone. The upper parts of the basal sandstone contain foliage of the coniferophyte *Cordaites*, and there are thin layers enriched in fine-grained sediment that are also mudcracked. The dark shale is clay rich and contains a well preserved flora dominated by cordaitalean foliage, with a moderately diverse assemblage of subsidiary taxa, possibly washed into the deposits, the most common of which mirror *Cordaites* in being typical of seasonally dry environments: *Walchia*, *Sphenopteridium*, *Charliea* and *Taeniopteris*. This flora includes a small mixture of more typically wetland plants, such as the pteridosperms *Neuropteris*, *Macroneuropteris*, and *Alethopteris*, calamitalean foliage, and the tree fern foliage, *Pecopteris*.The flora changes little upward, becoming increasingly fragmentary and allochthonous in character as the sediment becomes both coarser and less organic rich. The deposit terminates in a thin, 3-cm-thick coaly layer that is overlain by 25 cm of ripple-bedded sandstone. The thinly laminated shale (green to black in color) also contains a low-diversity fauna composed of bivalves, microconchids (spirorbids) and conchostracans, in addition to the xiphosurids. This fauna is not diagnostic of a particular salinity level, but it suggests that conditions were certainly not marine, though the presence of xiphosurids suggests a connection to a marine environment. Conchostracans, in particular, are consistent with conditions of intermittent dryness in the surrounding landscape. There is insufficient lateral exposure to characterize the geometry of this deposit, but the general features – a basal shallow-water, ripple laminated sandstone with evidence of subaerial exposure--suggests a channel with intermittent periods of low water. This channel was abandoned and flooded and may have become a lake, indicated by the organic shales at the base. Its proximity to marine strata (above and below) and the presence of xiphosurids suggests this was a coastal lake. Subsequent filling ensued and a swampy habitat developed at this site as the former channel filled.

EARLY PERMIAN TRACE FOSSILS FROM THE YESO GROUP, OTERO MESA, OTERO COUNTY, NEW MEXICO

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At Otero Mesa in Otero County, southern New Mexico, the Otero Mesa Formation of the Lower Permian Yeso Group is ~ 52 m of red-bed siliciclastic mudstone and ripple-laminated sandstone that is above the lowermost strata of the Yeso Group, which comprise an ~ 51 m thick interval of gypsum, gysiferous siltstone and dolomite. In 2012, we collected fossil plants and trace fossils in the Otero Mesa Formation at 17 localities along the western flank of Otero Mesa in sections 2, 11 and 14, T22S, R10E. These fossils occur primarily at two stratigraphic levels in the lower part of the Otero Mesa Formation. The lowest fossiliferous bed is ripple-laminated sandstone ~ 14 m above the base of the formation; the most fossiliferous bed is a similar sandstone ~ 6 m higher. The trace fossils occur in very fine grained sandstone or siltstone beds that have abundant ripple laminations (usually climbing ripples). Fossils from the Otero Mesa Formation are walchian conifers, invertebrate ichnofossils (*Augerinoichnus helicoidalis*, *Dendroidichnites irregulare*, *Scoyenia gracilis*) and tetrapod footprints (*Batrachichnus salamandroides*, *Dromopus lacertoides*, *Dimetropus* ichnosp.). The ichnoassemblage of the Otero Mesa Formation closely resembles those of the Abo and Robledo Mountains formations to the west, and well represents the *Dimetropus* ichnocoenosis of the *Batrachichnus* ichnofacies. It supports correlation of the Otero Mesa Formation to the lithologically similar Lee Ranch Member of the Abo Formation; both units yield ichnoassemblages of the *Dromopus* biochron. In contrast, ichnoassemblages of the lower part of the Yeso Group (Arroyo de Alamillo Formation) in central New Mexico (primarily Socorro County) are dominated by captorhinomorph tracks (especially of *Varanopus*), have only rare *Batrachichnus* and *Dromopus* and lack *Augerinoichnus*. The change in ichnoassemblages is the boundary between the *Dromopus* (older) and *Erpetopus* (younger) biochrons. Correlation of the Lee Ranch Tongue and Otero Mesa Formation, supported by lithologic similarity and trace-fossil biostratigraphy, identifies a diachronous base of the Yeso Group in the Sacramento Mountains-Otero Mesa area. Correlation of the Lee Ranch Tongue and Otero Mesa Formation to the Deer Mountain Red Shale Member of the Alacran Mountain Formation in the Hueco Mountains of West Texas identifies a single, red-bed interval during the late Wolfcampian and thus is the most parsimonious event stratigraphic correlation.

APPLICATION OF SEQUENCE STRATIGRAPHY TO OFFSHORE SHALE-RICH STRATA: UPPER CRETACEOUS MANCOS/COLORADO SHALE, SOUTHERN NEW MEXICO

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Intepretation of sequence stratigraphy in the middle Cenomanian-middle Turonian Tokay Tongue of the Mancos Shale and lower Tres Hermanos Formation, south-central New Mexico, and in the Colorado Shale, Atarque Sandstone, and lower Moreno Hill Formation, southwestern New Mexico, is hampered by widely spaced outcrops that are dominated by offshore marine shale. Our analysis focuses on the four best-exposed outcrops with the highest biostratigraphic resolution, which are, from southwest to northeast, in the Cookes Range (Luna County), at Mescal Canyon (Sierra County), in the Carthage coal field (Socorro County), and at Bull Gap (Lincoln County). In nearshore settings, sequence boundaries and falling stage systems tracts are defined by non-Waltherian, seaward shifts in facies, resulting in shoreline sandstones with erosional bases overlying offshore marine shales. Correlative sequence boundaries in offshore settings are represented by amalgamated storm sands or by sandy inoceramid-shell-rich calcarenites, although locally sequence boundaries are not recognizable within successions of offshore marine shale. Transgressive systems tracts are characterized by non-Waltherian, landward shifts in facies and are almost exclusively composed of offshore marine shale. However, the initial Mancos/Colorado transgression resulted in a thin (<1 m), transgressive lag composed of granular to pebbly sandstone. Condensed sections associated with maximum flooding surfaces are represented by thin, globigerinid wackestones and packstones, some of which are iron-rich and partially phosphatized. Upsection increases in the relative abundance and thickness of storm sands (progradational parasequence sets) define highstand systems tracts. Eight sequence boundaries are recognized in the ~200-m-thick interval. The lower five are dominated by distal shoreline facies and correlative calcarenites or amalgamated storm sandstones. Sequence boundary 6 at Mescal Canyon is at the base of the Atarque Sandstone Member of the Tres Hermanos Formation, which consists of a complete barrier island succession within the lower Turonian *Mammites nodosoides* Zone and correlates to calcarenites at the top of the Bridge Creek Limestone Beds of the Tokay Tongue of the Mancos Shale at Carthage. Sequence boundaries 7 and 8 at Carthage and Bull Gap are at the base and top of shoreline sandstones of the Atarque Sandstone Member, which at these locations is in the middle Turonian *Collignoniceras woollgari woollgari* Subzone and correlates to fluvial strata at Mescal Canyon and in the Cookes Range. This analysis is a high-resolution record of relative sea-level change within the previously defined T-1 transgression and R-1 regression of the Late Cretaceous Western Interior Seaway and provides outcrop analogs for evaluating the hydrocarbon potential of the Mancos Shale.

RECHARGING THE TULAROSA BASIN

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The Tularosa Basin Hydrogeology Study focuses on how recharge enters the basin from the east bounding mountains between Carrizozo in the north and Alamogordo in the south. To understand the mechanisms controlling recharge to the area a broad range of analysis were carried out. First, detailed geologic mapping at a scale of 1:24,000 was conducted, which provided us with an accurate understanding of the subsurface geology. Next, bi-monthly and continuous water-level measurements were collected from a network of appxomiately 100 wells for 2 years to provide insight on daily, monthly and seasonal fluctuations that occur in the aquifer system. Additionally, these water-levels were used to generate a regional water table map. Numerous geochemical analyses were conducted to help interpret the flow path of groundwater, identify the recharge areas, and evaluate the groundwater residence time. Lastly, to quantify how much groundwater is recharging the basin we performed a basic Darcy flow estimation. Darcy's Law requires knowledge of the saturated thickness of the aquifers present, which were able to estimate from the detailed geologic mapping, the hydraulic conductivity of the units, which was estimated from previous studies in the area, and the gradient of the water table, which was determined using the regional water-table map that we created.

Direct infiltration of precipitation to the basin floor in arid climates is typically negligible, due to limited precipitation volumes, high evaporation rates, and a deep water table. Instead, precipitation that falls on the neighboring mountains is typically the source of recharge for aquifers in the adjacent basins. There are two mechanisms that facilitate recharge from mountain precipitation to these basin aquifers; mountain-front recharge (MFR), and mountain-block recharge (MBR). MFR refers to water that recharges an aquifer as result of overland runoff that enters stream, and eventually infiltrates in the permeable alluvial fans the mouths of drainage basins on the valley floor. A previous USGS study (Waltemeyer, 2001) suggests that this is the primary source of recharge to the basin. Water-table mounding near the mouths of the drainage basins, as well as some geochemical results supports this. MBR refers to water that infiltrates to the high mountain aquifer, slowly flows through the mountain-block, flowing down gradient through the aquifers present, before entering the basin fill aquifer. There are several geochemical indications that some groundwater found in the basin was in prolonged contact with aquifers in the mountains, suggesting MBR.

To estimate the volume of recharge to the basin via MBR we looked at the difference between the Darcy flow calculations (67,900 AFY) and the USGS stream flow estimates (45,300 AFY). If the USGS study (Waltemeyer, 2001) accounts for all surface runoff entering the basin via MFR, and the Darcy calculation accounts for infiltrated surface water (MFR) and deeper flow paths (MBR), then we estimate that 33% comes from deeper flow paths, or mountain-block recharge.

References:

- Waltemeyer, S.D., 2001, Estimates of mountain-front streamflow available for potential recharge to the Tularosa Basin, New Mexico: U.S. Geological Survey Water-Resources Investigations Report 01-4013

FLUID FLOW AND GROUNDWATER MIXING: THE NACIMIENTO FAULT AND THE RIO SALADO, NEW MEXICO OR

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In the southwestern U.S., input of deeply-circulated groundwater has been shown to contribute to surface water salinization, degrading water quality. Fault structures can provide conduits for up- flow of these fluids.

Recent studies of the Jemez River, NM, indicate that where the river crosses faults, salinity and deeply derived volatiles increase, (e.g., prominent spring inputs at Soda Dam and concomitant production of travertine). In this tributary system to the Rio Grande, groundwater inputs profoundly affect surface water chemistry, raising concentration levels of several elements above EPA standards, particularly during low-flow conditions.

Rio Salado near San Ysidro provides another location to examine this phenomenon. Where the Rio Salado crosses the Nacimiento Fault, several springs discharge along the fault to the south and north of the river. Because the springs flow along the fault structure within and at a distance from the river, the effects of groundwater flow can be examined in greater detail. We report here the initial results of examining the hydrochemistry of the Salado and Nacimiento fault springs.

Two strategies were used, continuous monitoring of key hydrochemical parameters (temperature, specific conductance and depth) in four springs along the structure (including both sides of the river) and water chemistry, collected over a multi-year period. Seasonal and diurnal variations are seen as well as systematic depth (discharge) changes. Monitoring data highlight connectivity of three springs along the fault, while the fourth shows potential anthropogenic influences.

Fluid connectivity between springs is highlighted most prominently by near-synchronous changes in water depth of each spring. Seasonal variations are seen at all locations with 3 of the 4 springs displaying diurnal changes. Specific conductance does not correlate with water temperature or depth at all locations. This, in part, could be due to bioaccumulation on the data logger, reducing the accuracy of the reading. At one location, specific conductance shows two cyclical patterns which vary on the time scale of hours and days. During the summer months, both cycles of variation are present, while only the shorter-term variations are noted during the rest of the year.

Major ion chemistry from water samples collected over a multi-year period shows similar hydrochemical facies for three springs west of the river while samples from the east and the Rio Salado show greater temporal variability. Stable isotopes of water (dD and d18O) and carbon, as well as gas chemistry are also reported. The geochemical data support previous geophysical experiments at the site showing circulation patterns of saline fluids in the fault zone as well as showing slight temperature increases in the Rio Salado where it crosses the fault zone. Overall these combined data indicate that groundwater movement along faults is an important process that influences water quality in surface and aquifer waters.

INVESTIGATING THE MICROORGANISMS OF SUBSURFACE MINERAL ENVIRONMENTS

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The discovery of lava caves on Mars and lunar terrains has prompted the study of analogous environments on Earth to enhance our ability to detect life on extraterrestrial bodies. Such environments are lava caves that occur on Mauna Loa, Hawai`i. Lava caves contain secondary mineral deposits that appear non-biological, but reveal diverse microbial communities upon DNA sequencing. We hypothesize that secondary mineral deposits in lava caves contain a considerable number of microbial communities that vary among different mineral types, and can be investigated for multiple biosignatures. The investigation of these mineral deposits involves scanning electron microscopy (SEM) and sequencing, targeting the 16S rRNA SSU gene. SEM analysis of mineral deposits resulted in images depicting putative microorganisms: filamentous, coccoid, and bacillus morphologies present in biofilms. SEM images also depict mineral substrates having features that could be associated with microbial destructive activities. Collectively, our samples contain putative methane and hydrogen oxidizing bacteria, acidophilic and chemoheterotrophic bacteria, based on closest relatives. Investigating these microbes that masquerade as minerals, and the biosignatures associated with them can help in life detection efforts on extraterrestrial bodies and expand our knowledge of the microbial communities of oligotrophic caves on Earth.

LATE HOLOCENE ENVIRONMENTAL CHANGE AT CAÑADA ALAMOSA, NEW MEXICO, BASED ON SOIL STRATIGRAPHY AND CARBON ISOTOPES

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Astride the Rio Alamosa in south-central New Mexico is a stepped sequence of geomorphic surfaces that have developed in response to a changing flood plain base level. The topographically lowest and youngest surfaces have soils containing charcoal deposits that span a period from 3180 to 160 yr BP. These dates and soil stratigraphy indicate the Rio Alamosa flood plain and the alluvial fans grading to the flood plain aggraded until ca. 3000 BP when a sedimentation hiatus occurred. This permitted the formation of a prominent “A” horizon across the land surface of the alluvial fans. The land surface at that time, based on C isotopes, was occupied by dense grassland. The grass cover declined and alluviation recommenced around 2460 BP (during Antevs’ “Fairbanks Drought”) causing the landscape to aggrade until a second break in alluviation occurred at ca. 1900 yr BP. After this hiatus, alluviation started again, forming the third and uppermost deposit which correlates to the Medieval Warm Period (ca. AD 900-1300). This third unit, named Alamosa III, and the underlying units (Alamosa II and I) were incised by the arroyo network attached to the Rio Alamosa indicating a drop in base level. Backhoe trenches in the valley floor revealed buried “A” horizons 1 to 1.5 meters deep that contained charcoal dated at 550 and 350 yr BP. These buried land surfaces in the valley floor provide evidence that stream incision occurred during the Little Ice Age (ca. 1500-1850 AD) when erosion on the surrounding hillslopes was less active and the capacity for removing sediment from the valley floor by the Rio Alamosa was greater, thus dropping the base level. Since the end of the Little Ice Age erosion and sedimentation are again high as indicated alluvial fans building onto the modern floodplain and the landscape is once again aggrading.

CANOVAS CREEK: A PLEISTOCENE VERTEBRATE FAUNA FROM THE GILA REGION OF SOUTHWESTERN NEW MEXICO

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Canovas Creek is a late Pleistocene vertebrate fauna in the Gila National Forest, Catron County, southwestern New Mexico. Canovas Creek is one of the highest Pleistocene fossil sites in New Mexico at an elevation of 2,375 m (7,793 ft). The site was discovered in September 2010 by local resident Chris Wonderly and excavated by New Mexico Museum of Natural History field crews between 2011 and 2014. Vertebrate fossils are abundant in a layer about 50 cm thick, consisting of brown fine sand with silt and clay and occasional large rounded boulders up to 30 cm in diameter. The fossiliferous layer occurs over an area of about 25 m^2, and dips from the surface to a maximum depth of about 1.5 m in the center of the site where the sediments consist of medium to coarse sand, possibly representing a paleochannel structure.

The most common species in the Canovas Creek Fauna is the extinct horse *Equus conversidens*, represented by hundreds of isolated teeth, nearly 20 jaws and partial skulls, and about 10 complete limb bones. Second in abundance is the mammoth *Mammuthus columbi*, known from a pair of lower jaws, partial skull, 2 tusks, an isolated molar, several limb bones, and numerous vertebrae. Although sturdy elements such as isolated teeth, carpals, tarsals, and toes are common, incomplete bones are more abundant than intact fossils and there are thousands of bone fragments. The lack of articulated remains and abundance of broken and waterworn bones suggests the Canovas Creek fossils were transported by water under high energy, perhaps a flash flood, and secondarily redeposited. The rarity of freshwater species suggests the site of deposition was not a permanent water source such as a lake or stream.

The Canovas Creek Fauna consists of 18 species: the mud turtle *Kinosternon*, 2 birds, and 15 mammals. There are 5 members of the extinct Pleistocene megafauna: the horses *Equus conversidens* and *E. occidentalis*, giant llama *Camelops hesternus*, Stock's pronghorn *Stockoceros*, and Columbian mammoth *Mammuthus columbi*. Two medium-sized carnivores, bobcat *Lynx rufus* and coyote *Canis latrans*, still live in the Gila region. Large carnivores are currently unknown from the fauna. Small mammals include: shrew *Sorex*; 5 rodents, Wyoming ground squirrel *Urocitellus elegans*, red squirrel *Tamiasciurus hudsonicus*, northern pocket gopher *Thomomys talpoides*, woodrat *Neotoma*, and vole *Microtus*; and 2 rabbits, jackrabbit *Lepus* and mountain cottontail *Sylvilagus nuttallii*. *Tamiasciurus hudsonicus*, *Thomomys talpoides*, *Sylvilagus nuttallii*, *Sorex*, and *Microtus* are now restricted to montane habitats in New Mexico and no longer occur in the vicinity of Canovas Creek. *Urocitellus elegans* inhabits mountain meadows and sagebrush grasslands, and is currently unknown south of central Colorado. These small mammals occurred farther south and at lower elevations during the late Pleistocene when the climate was cooler and wetter. The presence of *Mammuthus columbi* and several extralimital species of small mammals suggest a late Pleistocene age (Rancholabrean) for the Canovas Creek LF.

THE EFFECT OF SOIL TEXTURE ON THE PRECIPITATION OF PEDOGENIC CARBONATE IN SEMI-ARID SOILS

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Calcic horizons are ubiquitous features of soils in the semi-arid Southwest US. Various factors, primarily moisture content, pH and pCO_2, influence the precipitation of carbonates within the soil profile. Calcium carbonate arrives at the soil surface along with dust, primarily silt and clay, so there is also a systematic increase in the silt and clay content of semi-arid soils with time. The accumulation of calcium carbonate over time produces systematic morphological and textural changes in soils described as stages of calcic horizon development. These changes in soil properties influence the partitioning of precipitation into infiltration and runoff in semi-arid environments. Decreasing water tables and increased societal demands on water supply pose an urgent need to understand the various controls on water movement in thick vadose zones to infer the water balance of the region.

Hydrus 1-D was used to understand how soil texture affects carbonate precipitation with depth in soils of Sevilleta National Wildlife Refuge, New Mexico. Model simulations were run comparing two fine textured soils, a sandy loam and a clay loam exposing them to identical boundary conditions. Meteorological and precipitation chemistry data recorded at Sevilleta Long Term Ecological Research (LTER) Bronco Well site were used as variable boundary conditions. Model results indicate that there is greater accumulation of calcite in soil with the sandy loam texture as compared to soil with the clay loam texture under similar climatic conditions. Sandy soils have higher infiltration rates as compared to clayey soils which accounts for greater accumulation of $CaCO_3$. The carbonate horizon is thicker in the sandy loam. The model results support field observations from soil profiles in the Bronco Well areas of Sevilleta where pedogenic carbonate has accumulated in sandy loam textured soils.

HYDROGEOLOGIC CONTROLS ON EARLY TRAVEL THROUGH THE JORNADA DEL MUERTO, NEW MEXICO

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El Camino Real was a 1,600 mile long trade route between Mexico and San Juan Pueblo, New Mexico between 1598 and 1882. It is commonly thought that the Jornada Del Muerto, located in southern New Mexico, was one of the most feared sections along the El Camino Real primarily due to the scarcity of water. Archaeologists have hypothesized that water availability largely influenced the travel route and locations of parajes (campsites) in the Jornada Del Muerto. In an effort to address this hypothesis, the main objective of this study is to assess spatial and temporal variability of water availability to travelers traversing the Jornada Del Muerto.

The Jornada Del Muerto, within the study area, is structurally characterized as a south plunging syncline bounded by the Caballo Mountains to the west and the San Andres Mountains to the east. The north-south trending Jornada Draw fault zone bisects the syncline, resulting in the exposure of Cretaceous and early Paleogene sandstones, sitstones and conglomerates on the west side of the study area. Water levels, isotopic and geochemical data indicate the presence of a shallow perched aquifer system in these rocks. This perched system is characterized by depths to water ranging from 180 feet to less than 20 feet below the surface. According to tritium concentrations, this shallow groundwater is composed of a mixture of modern water (<10 years old) and older water. This groundwater system responds quickly to wet and dry periods on the order of years to decades. This shallow system does not appear to be present east of the fault zone, where groundwater is significantly deeper (>200 feet) and older according to tritium analyses. Ojo Del Muerto spring, located at the northern boundary of the study area and on the west side on the surface water divide in the lower Rio Grande Basin, exhibits an apparent carbon-14 age of over 11,000 years before present, and therefore likely discharges water from a regional groundwater system which is less responsive to annual and decadal precipitation patterns.

Shallow water sources that were potentially available to El Camino Real travelers include seeps, springs, and playas. Simple hydrologic models were used to evaluate these water sources in terms of quantity and reliability. Ojo Del Muerto spring is likely the most reliable water source and produces enough water to support a medium sized group of up to 250 people and several hundred livestock. Playas undoubtedly supply the largest quantity of water, which could support large groups of up to 500 people and several thousand livestock. However, the occurrence of water in these playas is highly variable and therefore playas are a less reliable source. Seeps and local springs located in drainages produce significantly less water, but are more reliable than the playas. The two northern-most parajes in the study area are located near several of these water sources. Study results also have many implications for strategies used to navigate the Jornada Del Muerto.

ESTIMATING RECHARGE IN THE MIMBRES BASIN USING ENVIRONMENTAL TRACER ISOTOPES AND GIS

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Water is essential to life, without water life cannot exist. The use of ground water for basic essential uses (domestic and municipal) exert little pressure on a basin, its use for industrial and agricultural withdrawal, result in an extensive drawdown and dwelling water table in basin. Groundwater is an ideal source of fresh water for municipal, agricultural and industrial uses, primarily because of little to no treatment it requires. Estimating the volume of groundwater available in a basin is a daunting task, and no accurate measurements can be made. Water budgets and simulation models are primarily used to estimate the volume of water in a basin. With the recent advancement in geospatial science and water chemical analysis; chemical composition and age of ground water can be determined, which in turn can be used to estimate its recharge.Mimbres basin is located in southern New Mexico State of the USA, and extend southward into Mexico. Regions of active recharge and recharge rate was estimated in Mimbres basin, using the chloride environmental isotope; chloride mass-balance approach and GIS. Also, effect of elevation on recharge was determine in the basin. This research utilizes the chloride mass balance approach to estimate the recharge rate through collection of groundwater chemical data from wells, and precipitation. The data were analysed, cluster analysis, piper diagram and statistical significance were performed on the parameters of the groundwater; the infiltration rate was determined using chloride mass balance technique. The data was then analysed spatially using ArcGIS10.Mimbres basin regions of active recharge were identified, its recharge rate was 0.2153mm/yr (0.00848in/yr), and the elevation where active recharge occur was determined to be 1,500m. The results obtained in this study were consistent with result obtained by other researchers working in basins with similar semiarid mountainous conditions, thereby validating the applicability of CMB in the three basins.

U-Pb Geochronology of Sedimentary and Igneous Arc-Related Proterozoic Rocks in Southern New Mexico

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The Mazatzal province is thought to be a juvenile arc terrane that accreted onto southern Laurentia during the ~1.65 Ga Mazatzal orogeny. Thermal overprinting and local deformation during the emplacement of anorogenic granites at ~1.46 Ga has made it difficult to date Proterozoic fabrics and assign the deformation to either of these events. Detrital and igneous zircon U-Pb ages were obtained by LA-MC-ICPMS from four localities in southern New Mexico within the Mazatzal province. These localities include the Kingston District, Mud Springs, Caballo Mountains, and San Andres Mountains. These dates will be used to constrain the timing of deformation and the relationship of these rocks to the Mazatzal island arc system.

Detrital zircons were collected from quartzite, phyllite, a muscovite-biotite-quartz schist, a quartz-rich amphibolite, and conglomerate. Samples range from undeformed to highly deformed. Zircons from each sample form a single peak between 1.68–1.64 Ga. A slightly deformed quartzite from the Caballo Mountains yields the youngest maximum depositional age (MDA) of 1643±10 Ma (all uncertainties at 2s), while undeformed to slightly deformed quartzites in the San Andres yielded MDAs of 1652±6 Ma (Amato et al., 2008), 1675±16 Ma, and 1680±32 Ma. Two phyllites were dated from the San Andres and yielded MDA's of 1657±10 Ma and 1666±10 Ma. A quartz-rich amphibolite, with a possible sedimentary origin, from Mud Springs Mountain yielded a MDA of 1655±14 Ma. A conglomerate from the Kingston District has very little muscovite which suggests slight metamorphism; however, it appears to be undeformed. This samples yielded a MDA of 1661±42 Ma.

Zircons from granites, orthogneisses, and a gneissic granite were dated. A highly deformed gneissic granite from the Caballo Mountains yielded the oldest crystallization age of 1681±24 Ma. Several granites are either undeformed to only slightly deformed. These include San Andres granites at 1626±21 Ma (Serna, 2006), 1643±22 Ma, and 1679±46 Ma, and an undeformed granite from the Cookes Range at 1646±40Ma. An undeformed granite from the Kingston Mining District yielded a crystallization age of 1659±24 Ma. Orthogneisses from the San Andres yielded crystallization ages of 1647±14 Ma (Amato et al., 2008) and 1650±8 Ma. The youngest deformed igneous rock is an orthogneiss from the Florida Mountains that yields a crystallization age of 1623±14 Ma (Amato and Mack, 2012).

Some degree of deformation is found in all of the localities except the Kingston District where the undeformed conglomerate and undeformed granite were located. The other localities have ~1.4 Ga granites nearby which could have caused deformation in those areas, whereas the Kingston District rocks appear to have escaped significant deformation. If this is the case then much of the deformation in southern New Mexico could be linked to the ~1.4 Ga magmatic event and not the Matatzal orogeny.

References:

- Amato and Becker, 2012, NMGS Guidebook 63, p. 227-233
- Amato and Mack, 2012, GSA Bulletin, v. 124, p. 1826-1840
- Amato et al., 2008, GSA Bulletin, v. 120, p. 328-346
- Serna, A.M., 2006, NMSU M.S. Thesis, 89 p

EMPLACEMENT OF ZEBIN HILL, JICÍN VOLCANIC FIELD, BOHEMIAN PARADISE, CZECH REPUBLIC

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The Jicin Volcanic Field, Czech Republic preserves a well-preserved set of Middle Miocene scoria- and tuff-cones and their feeders. Zebin Hill is a tuff cone that has been quarried to reveal the volcanoes feeder system. This edifice offers the opportunity to understand how magma is transported through a monogenetic pyroclastic cone. Rock types include a coarse-grained basal phreatomagmatic layer and a stratified upper wall facies both of which are penetrated by feeder dikes. The character of magmatic fragments suggests quench fragmentation during a phreatomagmatic eruption. Anisotropy of magnetic susceptibility (AMS) data were collected at twenty-one sites from feeder dikes and the main conduit of the volcano. Magnetic susceptibility intensity ranges from 100E-3 to 300E-3 SI indicating that the dominant magnetic mineral is a ferromagnetic phase with little contribution from paramagnetic minerals. AMS ellipsoids shapes are both oblate and prolate with the shape varying across the intrusions. Curie point estimates yield a spectrum of results indicating a mixture of magnetic minerals from high-Ti titanomagnetite, iron sulfide, and low-Ti titanomagnetite. The AMS inferred magma flow directions yield flow away from the central vent area and subhorizontal flow towards and away from the axial conduit; both upward and downward magma flow is evident at some sites. Paleomagnetic data reveal a high coercivity normal polarity magnetization that varies spatially between the sampled sites. We interpret these data to indicate that subvolcanic deformation occurred during the emplacement of the dikes; although we can not rule out the possibility that the dispersion between sites represents secular variation. We find this unlikely given the short lived emplacement time scale (< 10E1 yrs) for the growth on monogenetic volcanoes. The simple external structure of cinder cones hides a rather complex magmatic plumbing system that continues to evolve during the life of the volcano. The growth of many volcanoes occurs not due to a simple central axis feeder system but rather through interplay of local structures, magmatic effects, and constructs evolution throughout the life time of the volcano. The comparison between structural observations, paleomagnetic, and AMS show that these methods provide valuable complementary data on dike propagation and subsequent magma flow.

EVALUATING QUATERNARY TRAVERTINE DEPOSITS OF THE RIO GRANDE RIFT AND COLORADO PLATEAU: GEOCHEMICAL SIGNATURES OF TRAVERTINE FACIES AND QUANTIFICATION OF LONG-TERM CO_2 LEAKAGE ALONG FAULTS, WITH IMPLICATIONS FOR CO_2 SEQUESTRATION

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Large-volume Quaternary travertine deposits in New Mexico and Arizona occur along the Rio Grande rift and on the southwestern Colorado Plateau. The travertines formed due to the degassing of CO_2 from carbonic groundwater supersaturated in calcium carbonate that migrated up fault systems towards the surface. U-series dating shows that large volumes (2.5 km^3) of travertine accumulated episodically at times of both increased magmatic activity (high CO_2 flux) and recharge (high hydraulic head) in confined aquifer systems. Depositional environments of travertine, e.g. spring mound and marsh, produce distinctive travertine facies such as step-pool, paludal (marsh), and vein facies. Stable oxygen and carbon isotope values of the different travertine deposits overlap substantially, with $\delta^{18}O$ and $\delta^{13}C$ ranging from -14‰ to -3.8‰ and -4.9‰ to 9.8‰, respectively. The range in oxygen isotopes represents mixing of different types of groundwater and varying water temperature, whereas carbon isotopes are mainly influenced by the degassing of CO_2. Preliminary results of trace element analyses show similar trends throughout the region, with high (> 1000 mg/kg) concentrations of Fe, Mg, Mn, Na, and Sr. Different travertine facies have different stable isotopic and geochemical compositions. For example, most of the $\delta^{13}C$ values of the paludal facies vary between -1‰ and -5‰ as opposed to the step-pool facies where most $\delta^{13}C$ values range from 2‰ to 7‰, and the vein facies shows higher concentrations of certain trace elements (e.g., Fe, Ni, and Sr).Travertines are natural analogues for CO_2 leakage along fault systems that bypassed regional cap rocks, such as shales of the Triassic Chinle Formation. The volume of the travertine can be used to infer the integrated CO_2 leakage along a fault system over geologic time. This leakage is estimated (as a minimum) as: (1) CO_2 that becomes fixed in $CaCO_3$/travertine (tons of carbon converted into tons of carbonate), (2) the amount of CO_2 that degassed into the atmosphere (twice the amount of (1), based on reaction stoichiometry), (3) dissolved CO_2 that is carried away with the water discharging from a spring (based on modern spring discharge and dissolved carbon content), and (4) CO_2 that escapes through the soil (based on modern soil flux measurements). The total CO_2 leakage (1and 2) calculated for the study areas in New Mexico and Arizona is estimated as ~6 Gt (gigatons), whereas the integrated CO_2 leakage (1-4) is estimated as ~128 Gt. Better understanding of integrated CO_2 leakage and fault-related seal bypass is needed to design CO_2 sequestration sites to effectively store anthropogenic CO_2 in the subsurface.

A NEW SPECIMEN OF PLESIORHINEURA TSENTASI: THE OLDEST KNOWN RHINEURID AMPHISBAENIAN FROM THE PALEOCENE (TORREJONIAN) OF NEW MEXICO

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Amphisbaenia is a group of worm-like lizards that includes both extant and extinct species. The family Rhineuridae is the only known amphisbaenian family restricted to North America. The taxon Plesiorhineura tsentasi is the oldest (Paleocene, Torrejonian) known rhineurid in the fossil record and, recent phylogenetic studies show that rhineurids are the basal group of the Amphisbaenia. The holotype of Plesiorhineura tsentasi (NMMNH [New Mexico Museum of Natural History] P-12347, formerly UNM [University of New Mexico] NP-595) is known by the medial portion of the right jaw. The holotype was collected from the Nacimiento Formation at locality NMMNH L-312 (BUNM 77-184) in Torreon Wash, New Mexico. A recently collected specimen (NMMNH P-59245), which also represents the medial portion of the right jaw, came from the same locality and is considered to be a topotype of this taxon. The topotype has three teeth, of which the ior-most is complete. It is missing the coronoid, splenial, and the anterior extension of the surangular, and thus is comprised solely of the dentary. The topotype conforms in every way to the holotype and is clearly referable to P. tsentasi based on its near identical morphology. Both specimens represent the same portion of the right dentary, suggesting this section is the most durable part of the lower jaw.

ABRUPT OPENING OF THE RIO GRANDE RIFT ~20-10 MA DUE TO FRAGMENTATION OF THE FARALLON SLAB: EVIDENCE FROM APATITE (U-TH)/HE AND FISSION TRACK THERMOCHRONOLOGY

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152 new apatite (U-Th)/He dates are presented from 34 sample locations along the flanks of the Rio Grande rift in New Mexico and Colorado. These data are combined with existing apatite fission track analyses of the same rocks and modeled together to create well constrained cooling histories from ~120-30 °C for the rift flanks. When combined with existing apatite (U-Th)/He dates from northern Colorado, these data together encompass >850 km of the length of the Rio Grande rift, and provide the time-space constraints needed to test geodynamic models for initiation and evolution of continental rifting. The new data and cooling models indicate that the rift opened simultaneously and abruptly from northern Colorado to southern New Mexico, with large magnitude fault slip and exhumation of rift flanks between ~20-10 Ma.

We propose a new geodynamic model of near-synchronous extension involving tearing and ultimate foundering of the Farallon slab that was controlled by thick cratonic keels beneath Wyoming, the Great Plains, and western Texas/southeastern New Mexico. As the shallowly-subducting Farallon slab encountered these thicker regions it was forced to tear and decouple from the base of the North American lithosphere. Incoherent foundering of the slab in the Oligocene is evident in the migration of silicic calderas through time. The San Juan volcanic field in Colorado displays a SW sweep in volcanism, the Mogollon-Datil volcanic field in New Mexico displays a NW sweep in volcanism, and the Trans-Pecos volcanic field in Texas displays a SW sweep in volcanism. In our model, lithosphere delaminations and associated ~35-25 Ma ignimbrite events led to near-simultaneous tearing and foundering near the bend in the Farallon slab from northern Colorado to southern New Mexico in the region underlying the present-day Rio Grande rift. This event triggered small-scale mantle convection and a change in crustal stress regimes that ultimately drove near-synchronous surface extension ~20-10 Ma. Our model accounts for the observed temporal and spatial patterns of extension along >850 km of the length of the Rio Grande rift while placing these results within the Cenozoic tectonic and magmatic history of western North America.

PROGRESS REPORT ON SUBTLE TECTONIC FEATURES INFLUENCING PATHS OF SMALL TO LARGE DRAINAGES CROSSING THE SOUTHEASTERN ALBUQUERQUE BASIN, NEW MEXICO

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Paths and patterns of drainages ranging from first-order swales, to larger Abo Arroyo, to the Rio Grande show subtle influences of recently recognized tectonic features in the southeastern Albuquerque basin. Buried structures seen geophysically between the southeastern flank of the Belen subbasin and the mountains to the east have been interpreted as a bedrock high extending northeast from the Joyita Hills. The main subsurface mass extends approximately 20 km east-to-west from the Los Pinos and southern Manzano Mountains to the edge of the modern Rio Grande valley and 30 km southwest-to-northeast from the Joyita Hills to a deep subbasin west of the Hubbell Spring bench. The mass has a steep gravity gradient along its northwestern flank, striking north-northeast. The mass also has highs such as Turututu and lows such as a graben between the Los Pinos Mountains and a Proterozoic outcrop 10 km west of the range. Expression of deformation at the surface is restricted to degraded low-relief fault scarps and peculiar drainage paths. Cibola Canyon and Palo Duro Canyon constructed large fans from the southern Los Pinos Mountains across the area north of the Joyita Hills, but both drainages established entrenched courses trending northwest to join the Rio Grande at upstream obtuse angles. Maes Arroyo and Pino Draw established similar northwest-trending paths. Abo Arroyo deposited a sequence of large fan segments east-west across the buried feature; its present valley veers northwest and west near its junction with the Rio Grande. Abo Arroyo and smaller adjacent drainages are influenced by north-south down-to-the-east normal faults that cut the older segmented fan. These subtle effects suggest multiple scales of interaction between structure, drainage systems, and time, ranging from local stream gradients crossing or paralleling a single fault to the deflection of drainage directions across fans of the large tributaries.

South of Turututu the local graben deflects alluvial fans to the northwest and into north-south swales abutting an east-dipping fault. Given limited soil development and older ancestral Palo Duro deposits interfingering with Rio Grande deposits (obsidian clasts <1.4 Ma) immediately to the west, the west side of the graben has dropped recently. To the north of the graben, Pino Draw reworked Abo fan and Rio Grande sediments north and south of Turututu and built low terraces to the east of the 5-m scarp of an E-dipping normal fault. Pino Draw flattens across the half-horst west of the fault and then steepens on the western edge. Between Turututu and Abo Arroyo, the west-tilted half-horst consisting of a beheaded paleo-Abo fan complex forms a N-S bluff line for ancestral Rio Grande deposits containing obsidian. The post-bluff-line Pleistocene to Holocene swales cutting through the half horst have been uplifted, and occasionally beheaded. Swales have re-oriented recently, turning north-south along the eastern edge of the horst. The largest swales have occupied the same breaches through the half-horst since mid-Pleistocene time. Smaller swales have been isolated through the last ~300-kyrs. The E-dipping fault has continued to slip, shown by small offsets in <100 kyr Abo Arroyo terraces.

MINERALOGY, GEOCHEMISTRY, AND CHRONOLOGY OF THE CABALLO AND BURRO MOUNTAINS REE-BEARING EPISYENITES

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Extraordinarily potassium feldspar-rich, brick-red rocks, termed “episyenites”, in the Caballo and Burro Mountains, New Mexico, have anomalously high concentrations of U, Th and REE. Field and electron microprobe investigations of outcrop distribution and mineralogical textures suggest episyenites formed by interaction of K-rich metasomatic fluids with Precambrian granitic host rocks, resulting in K-feldspar-rich rocks with bulk compositions of up to 16 wt.% K2O. The secondary feldspars are significantly less fractured than primary igneous feldspar, display no perthititic textures, and contain micron size hematite inclusions. The most reddened episyenites are composed largely of interlocked K-feldspar crystals which display no igneous texture. Investigation of rocks with the highest concentrations of U, Th, and REE indicate complex mineralogy associated with fluid alteration, particularly of primary magmatic mafic silicates, now replaced by a combination of secondary chlorite, hematite, carbonate, apatite, rutile, synchysite, aeschynite, thorite, uranophane and xenotime. In the Caballo Mountains, timing of metasomatism is constrained to be older than late Cambrian as episyenite clasts occur in the C-O Bliss Sandstone that unconformably overlies metasomatised basement. Direct dating of the metasomatism using the $^{40}Ar/^{39}Ar$ method on sub-milligram fragments of metasomatic K-feldspar yield complex and intriguing age results. In the Caballo Mts. age spectra range from nearly flat to highly disturbed with total gas ages (TGA) between approx.40 and 460 Ma. Individual fragments with flat spectra from single samples vary in TGA by approx.140 Ma (approx. 320 to 460 Ma). The overall youthfulness of the results is not compatible with the hypothesis that a single metasomatic event related to regional C-O alkaline magmatism was responsible for all metasomatism. However, one sample from the Burro Mts. yields a plateau age at approx. 540 Ma that may record late Cambrian metasomatism caused by an alkaline or carbonatitic intrusion in the subsurface.

EVIDENCE AND CONTEXT FOR 1.45 GA MAGMATISM IN THE LAS VEGAS RANGE, NEW MEXICO

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The 1.45 Ga Evergreen Valley Plutonic Complex (EVPC) is a bimodal layered plutonic complex exposed in the Las Vegas Range of the southern Sangre de Cristo Mountains of New Mexico. The complex is an east-west trending 2 km x 1 km elliptical body that cross-cuts a 1.7 Ga garnet tonalite and is in unconformable contact with Paleozoic sedimentary rocks at its north and south contact. The EVPC consists of two main units: a massive coarse subhedral granular granite that comprises the eastern two-thirds of the complex and a quartz monzogabbro unit that encompasses the western third. The granite contains major microcline, quartz, plagioclase, biotite and accessory magnetite, epidote, and zircon. The granite is homogeneous in mineralogy and isotropic in texture. The quartz monzogabbro contains major but variable amounts of plagioclase, hornblende, biotite, quartz, microcline, and epidote and accessory titanite and magnetite. The quartz monzogabbro is separated from the main granite by an ~ 30m zone of magma mingling. This commingling zone contains several 0.5-1.0-meter thick alternating southwest-dipping mafic and felsic layers. The complex also presents field relations such as silicic pipes and load ball structures, which are consistent with an origin as a mafic-silicic layered intrusion. Contacts between the mafic and felsic units are sharp but interdigitating indicating that the mafic-felsic units were comagmatic. While the EVPC demonstrates magmatic layering, it lacks an internal plutonic foliation and other features characteristic of circa 1.4 Ga synorogenic plutons in the U.S. southwest.

THE RARE AMMONITE *HOURCQUIA MIRABILIS* FROM THE UPPER CRETACEOUS JUANA LOPEZ MEMBER OF THE MANCOS SHALE, SANDOVAL AND SANTA FE COUNTIES, NEW MEXICO

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Hourcquia mirabilis is a very rare ammonite in the Upper Cretaceous of the Western Interior. We report four additional specimens of *H. mirabilis* from the middle shale interval of the Juana Lopez Member in Sandoval and Santa Fe counties, NM. Three localities are east of Mesa Prieta in Sandoval County, and one is from the type area of the Juana Lopez Member at Galisteo Dam in Santa Fe County. They occur in the middle Turonian *Coilopoceras inflatum* Subzone in the upper part of the *Prionocyclus macombi* Zone. Distinguishing features of the newly discovered specimens include an involute shell with a trapezoidal whorl section, a fastigiate venter with a prominent siphonal keel and strong, straight, rounded, prorsiradiate primary ribs that arise from strong umbilical bullae and terminate in strong, blunt ventrolateral nodes, as has been previously described in *H. mirabilis*.

Hourcquia mirabilis has also been reported from the *Prionocyclus macombi* Zone in association with *Coilopoceras inflatum* in the basal 1.5 m of the D-Cross Tongue at Mescal Canyon in Sierra County and in the basal sandstone of the Juana Lopez at Bull Gap Canyon in Lincoln County, where it is also associated with *C. inflatum* (Hook and Cobban, 2013). It has also been reported near the base of the Juana Lopez Member at Taylor Springs in Colfax County and near the base of the Juana Lopez at the type locality (Kennedy et al., 1988). *Hourcquia* is a very rare ammonite, known in the USA from the middle Turonian zones of *P. macombi* in New Mexico and (questionably) *P. wyomingensis* in Trans-Pecos Texas (Kennedy et al., 1989). Leckie et al. (1997) also reported *H. mirabilis* from the Juana Lopez Member near Mesa Verde, Colorado. *Hourcquia* has also been described from Madagascar, Japan, Sakhalin (Russia) and Venezuela (Kennedy et al., 1988). This is the first report of *H. mirabilis* from Sandoval County.

References:

- Hook, S. C. and Cobban, W. A., 2013, The Upper Cretaceous (Turonian) Juana Lopez beds of the D-Cross Tongue of the Mancos Shale in central New Mexico and their relationship to the Juana Lopez Member of the Mancos Shale in the San Juan Basin: New Mexico Geology, vol. 35, no. 3, p. 59-81.
- Kennedy, W. J., Cobban, W. A. and Hook, S. C., 1988, *Hourcquia* Collignon, 1965 (Cretaceous Ammonoidea) from the upper Turonian of the southern United States: Paläontologische Zeitschrift, v. 62, issue 1-2, p. 87-93.
- Kennedy, W. J., Cobban, W. A., Hancock, J. M. and Hook, S. C., 1989, Biostratigraphy of the Chispa Summit Formation at its type locality; a Cenomanian-Turonian reference section for Trans-Pecos Texas: Geological Institutions of the University of Uppsala, Bulletin, n. ser., v. 15, p. 39–119.
- Leckie, R. M., Kirkland, J. I., and Elder, W. P., 1997, Stratigraphic framework and correlation of a principal reference section of the Mancos Shale (Upper Cretaceous), Mesa Verde, Colorado: New Mexico Geological Society, Guidebook 48, p. 163-216.

THE ROLE OF CRUSTAL ASSIMILATION DURING THE PETROGENESIS OF THE BANDERA FLOW, ZUNI BANDERA VOLCANIC FIELD, WEST-CENTRAL NEW MEXICO

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Whole rocks and phenocrysts in young alkaline basalts from west central New Mexico are used to distinguish between magmas that result from melting of heterogeneous mantle sources and melting of a single asthenospheric source in which magmas have been variably contaminated with felsic crust during ascent. The 11.6 ka Bandera flow is the youngest alkaline basalt flow in the Zuni Bandera Volcanic Field (ZBVF), a volcanic field located along the Jemez Lineament, northeast-trending suture zone situated between the Colorado Plateau and the Rio Grande rift. Bandera basalts have OIB like trace element signatures (Peters et al., 2007).

Whole rock major elements show little variation suggesting minimal crystal fractionation (1-5%). However, trace element variation within Bandera basalts would require fractionation of approximately 10-30% of the original magma to produce observed trace element enrichments. Whole rock trace elements appear to result from the mixing of two compositional endmembers. Major element variations of olivine hosted melt inclusions are consistent with variations resulting from crystal fractionation. However, trace element variations of melt inclusions are consistent with magma mixing or crustal assimilation.

Variable $^{87}Sr/^{86}Sr$ and $^{206}Pb/^{204}Pb$ ratios are inversely correlated, confirming involvement of at least two sources in the petrogenetic history of the Bandera flow. $^{87}Sr/^{86}Sr$ ratios range from 0.7028 to 0.7040 and $^{206}Pb/^{204}Pb$ ratios range from 19.017 to 19.307. Plagioclase and olivine phenocrysts, and quartz xenocrysts, have $^{87}Sr/^{86}Sr$ ratios that differ from host whole rock signatures. The $^{87}Sr/^{86}Sr$ ratio of a plagioclase phenocryst (0.70420±0.00003) differs from the host whole rock (0.70370±0.00002) suggesting that open system modification of Bandera magmas occurred at crustal depths, more consistent with crustal contamination rather than magma mixing. Results of this study may add insight to the effects of crustal contamination in the generation of continental alkali basalts more regionally and throughout the western United States

References:

- Peters, T.J., Menzies, M., Thirlwall, M., Kyle, P.R., 2007, Zuni-Bandera volcanism, Rio Grande, USA – Melt formation in garnet- and spinel- facies mantle straddling the asthenosphere- lithosphere boundry. Lithos 102, p. 295-315

CHARACTERIZATION OF PLAYA LAKE SOIL AND SEDIMENT IN THE LAS VEGAS NATIONAL WILDLIFE REFUGE: IMPLICATIONS FOR NATURAL RESOURCE MANAGEMENT

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Numerous waterfowl and other wildlife species inhabit the playa lake environment at the Las Vegas National Wildlife Refuge. These biotic communities in the refuge ecosystem rely upon sporadic freshwater inflows from surface runoff or deliveries from the Storrie Lake Project conveyance system. When available during non-drought years, the majority of this irrigation water is transported to, stored in, and allocated from several playa lakes located within in the refuge. The quality of soil and sediment that has developed over time on the surface of these playa lakes is critical to water resource management efforts within the refuge. Since these playa lakes exist within a partially closed basin system in the semi-arid region of New Mexico, accumulation of salt minerals and other nutrients within the lakes has become of principle concern. Therefore, the physical and chemical characteristics of this mineral-, nutrient- and moisture- rich surface layer of sediment and soil are vital to understanding the hydraulic properties of the playa ecosystem. A detailed analysis of physical and geochemical properties of soils in each of the playa lakes is fundamental to water and wildlife resource management efforts, specifically, as these properties relate to the transport, storage and allocation of water resources in refuge lakes. As such, the following sedimentological study presents the results of efforts to classify, characterize, and compare the soil and sediment in each of these playa lakes. Analysis and interpretation of data revealed in this study are then used to develop specific water use recommendations and goals for natural resource management personnel at the Las Vegas National Wildlife Refuge.

NEWLY DISCOVERED DINOSAUR FOSSILS FROM THE UPPER CRETACEOUS (LATE MAASTRICHTHIAN) MCRAE FORMATION, SIERRA COUNTY, NEW MEXICO

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Fossil dinosaur remains from the Upper Cretaceous McRae Formation in Sierra County, New Mexico, have been collected and studied for over a century, albeit sporadically. Dinosaur taxa that have been previously reported include *Tyrannosaurus rex* (although probably representing a different species of that genus), *Alamosaurus* sp., an ankylosaurid, and large fenestrate chasmosaurines tentatively referred to as *Torosaurus*, but which likely represent a new taxon.This assemblage has led to an age assignment of Late Maastrichthian (Lancian), however that age assignment needs more robust biostratigraphic data to be verified.Given that dinosaur fossils are used to assign an age to the McRae Formation and that the assemblage may contain taxa which are of uncertain taxonomic placement, all new materials have potential biostratigraphic and/or taxonomic value. Recently, field parties from the New Mexico Museum of Natural History and Science have made an attempt to revisit previously reported dinosaur localities not currently submerged by Elephant Butte Reservoir as well as prospect for new localities. Newly discovered dinosaur material includes a partial hadrosuarid post-cranial skeleton, an unusually large ceratopsid epijugal from a previously known locality as well as numerous large indeterminate specimens awaiting excavation. These new discoveries are from the middle to upper part of the Hall Lake Member and will provide data to determine the upper age limit of the McRae Formation.

THE 1941 PROJECT: A METEOROLOGICAL REANALYSIS INVESTIGATION INTO AN ABNORMAL YEAR OF PRECIPITATION

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This project is an observational investigation of the wettest year on record in New Mexico, the year 1941. Many different variables and climatic indices are examined, including the Palmer Drought Severity Index (PDSI), monthly precipitation statistics, temperature, monsoon rainfall, sea surface temperature (SST) anomalies, weather map analysis, tropical storm remnants, synoptic-scale composites, analysis of individual conditions that produce certain storm events, and external factors such as El Niño-Southern Oscillation indices over various spatial and temporal extents. In particular, extensive use is made of a new large-scale data set generated from a 20th Century "reanalysis". The reanalysis uses historical surface data that is assimilated by a modern atmospheric general circulation model with a consistent analysis scheme, essentially using the model to carry out a three-dimensional dynamical interpolation of sparse data using just surface weather data to anchor the analysis. The reanalysis product yields reconstructed three-dimensional weather information for an era in which there are no direct upper air measurements. The overall goal of this project is to explore why the year 1941 was so abnormal for the state of New Mexico in terms of precipitation, allowing me to assess whether these conditions are likely to occur again. It was found that a combination of the highest Pacific Decadal Oscillation (PDO) value with a moderate El Niño led to large precipitation anomalies region-wide that are consistent with an El Niño event. In conclusion, a widespread precipitation anomaly like the one that occurred in 1941 is a low-probability event based on the severity, area, and duration of the precipitation anomaly that was generated.

CHARACTERIZATION OF CLAY AND ASSOCIATED MINERALS AT THE NORTHSTAR MINE, MAIN TINTIC DISTRICT, JUAB COUNTY, UTAH

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Northstar Clay Mines LLC currently operates the Northstar Mine, located near Mammoth, Utah in the Main Tintic District of Juab County. The mine supplies a local concrete plant with clay and iron-oxide, however the company is interested in marketing the specialty clay, halloysite. The clay deposits from this district have previously been documented to contain halloysite and kaolinite, however little is known about their purity and associated minerals. This study uses crystal imaging and x-ray diffraction to determine abundance and mineralogy of clays and other minerals in the Northstar clay deposit.

Samples pertaining to the Northstar clay deposit were collected from pits, adits, and the surface along a cross-section that reflects a horizontal and vertical extent of the deposit. The Cameca SX-100 microprobe and scanning electron microscope (SEM) produced high-resolution secondary electron images from chip-samples of the clays. Random powder mounts of the clays were made by wet-crushing with acetone. The Panalytical X'pert Pro X-Ray Diffraction (XRD) unit analyzed the random powder mounts to determine mineral identification.

Samples provided a distribution of halloysite and kaolinite, with some mixing of illite. Much of the clay deposit is dominated by iron (Fe)- and manganese (Mn)-enrichment, respectively through goethite and lithiophorite. Aluminum (Al)-enrichment occurs selectively as gibbsite and alunite.

The pure white halloysite clay can be confirmed by SEM imaging and XRD peak identification. SEM imaging also displays halloysite in the Fe- and Mn-enriched samples, however the XRD Fe-background is too high to display clay peaks for identification. Future work will include back scatter imaging and spectroscopy chemical mapping with the SEM. Additionally, the Fe-enriched clay samples will be further processed to reduce iron so that clay identification can be possible through x-ray diffraction.

MAGDALENA, NEW MEXICO WATER CRISIS – THE DAY THE WATER DRIED: A HYDROGEOLOGIC PERSPECTIVE

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For most of June 2013, the Village of Magdalena could not produce water from their only well. It did not have sufficient water to pump; it had gone "dry." Without being able to fill their Village storage tanks and supply the community, they were forced to truck in tanks of water and use bottled water. Over the following months, old wells were rehabilitated and the primary well gradually recovered enough water to produce again.

In reaction to the water outage in June, broad community concern developed about the local groundwater resources. To help address this concern, the New Mexico Bureau of Geology and Mineral Resources' Aquifer Mapping Program began a watershed-scale hydrogeologic assessment. In this region of New Mexico, groundwater is found within fractured/faulted bedrock aquifers and thin alluvial aquifers. Wells are typically poor producers, commonly with 3-5 gallons per minute (gpm), while very few produce more than 100-200 gpm. Wells that can produce higher volumes are located in close proximity to the Magdalena Fault, which trends northeast-southwest through town.

During the summer of 2013, depth to water measurements were collected from 37 wells including Village and private domestic wells. Water level measurements were repeated in most of these wells in September 2013 and March 2014, in addition to installation of two continuous water level monitoring devices.

Looking at long-term trends, historical data from well drillers' records and a water table map in a report by Summers (1975) provide a "baseline" for water levels in the area. Comparisons with the historic water levels suggest that in 2013, approximately 70% of the wells we measured had declines in water levels. Larger ~200-foot declines are observed on the east side of the Village, generally proximal to their primary pumping well.

Within a short-term perspective of 2013 and 2014, changes in depth to water are quite variable, which reflects the compartmentalized nature of the aquifers. Despite the sparse winter precipitation, most wells have higher water levels in March 2014 than in the summer of 2013. Since the water "crisis" in Magdalena in June 2013, water usage has also declined significantly. Continuous monitoring nearby the Villages' primary pumping well shows that water levels have risen approximately 25 feet since that well "dried" up in June 2013.

As New Mexico faces challenges of reduced surface water supplies, with increasing temperatures and evaporation rates in the future, groundwater will become our most important resource. In areas like Magdalena with locally complicated geology, developing a detailed understanding of the regional geology, and how groundwater moves within it, is essential to a community's future water supply.

Reference:

- **Summers, W.K.**, 1975, Ground-water resources of the Village of Magdalena, Socorro County, New Mexico: A hydrologic report on the results of test drilling during February 1975, Santa Fe, Consultants Report to Ralph E. Vail, 17 p.

GEOLOGIC MAPPING AND GEOCHRONOLOGY OF PROTEROZOIC ROCKS IN THE BURRO MOUNTAINS, NEW MEXICO REVEALS A NEW GRENVILLE LOCALITY IN THE SOUTHWEST U.S.

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Metasedimentary rocks in the northern Burro Mountains have an uncertain age, depositional setting, and tectonic significance. Amato et al. (2008) dated two samples within a phyllite unit located in the eastern region of the Redrock area, and reported maximum depositional ages (MDA) of 1753 Ma (n=73), and 1673 Ma (n=44). U/Pb detrital zircon dates and field mapping from this study have identified five distinctive metasedimentary units within the Redrock area, and the zircon ages indicate that some of these units were deposited >400 m.y. later during the Grenville Orogeny. A biotite-albite-actinolite schist in the western part of the field area has a MDA of 1233 ± 11 Ma (n=38), and a metacarbonate unit, also located in the western region, has a MDA of 1230 ± 11 Ma (n=28). A more metamorphosed phase of the phyllite adjacent to these units has been dated at 1643 ± 26 Ma (n=28) and is part of the Mazatzal province sedimentary protolith section. The schist and metacarbonate units are intruded on the west by 1.23–1.22 Ga granite and anorthosite (Rämö et al., 2003; this study). These ages and field relationships are consistent with deposition of sediments in a back arc basin during Grenville extension, and bimodal magmatism ~5-10 m.y. later which resulted in the intrusion of the granite suite. These field relationships indicate that there is an unconformity between Mazatzal-age (1.7-1.6 Ga) and Grenville-age (1.2 Ga) sedimentary rocks in the western region of the Redrock area. In addition, at least two generations of normal faults post-date the deposition of these sediments, creating complex structural relationships. Results from this study suggest a previously unrecognized Grenville basin in the Burro Mountains.

References:

- Amato, J.M., Boullion, A.O., Serna, A.M., Sanders, A.E., Farmer, G.L., Gehrels, G.E.,and Wooden, J.L., 2008, Evolution of the Mazatzal province and the timing of the Mazatzal Orogeny: Insights from the U-Pb geochronology and geochemistry of igneous and metasedimentary rocks in southern New Mexico: Geological Society of America Bulletin, v. 120, p. 328–346.
- McLemore, V.T., Dunbar, N., Kosunen, P.J., Rämö, O.T., Heizler, M., and Haapala, I., 2002, Geology and geochemistry of the Redrock granite and anorthosite xenoliths(Proterozoic) in the northern Burro Mountains, Grant County, New Mexico, USA: Bulletin of the Geological Society of Finland, v. 74, p. 7–52.
- Rämö, O. T., McLemore, V. T., Hamilton, M. A., Kosunen, P. J., Heizler, M., and Haapala, I., 2003, Intermittent 1630-1220 Ma magmatism in central Mazatzal Province; new geochronologic piercing points and some tectonic implications: Geology, v. 31, p. 335-338.

SMALL THEROPOD TEETH FROM THE LATE CRETACEOUS OF THE SAN JUAN BASIN, NORTHWESTERN NEW MEXICO

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Isolated teeth provide the primary evidence for the presence of small theropod dinosaurs in the Late Cretaceous of the San Juan Basin, northwestern New Mexico. Specimens are from the Santonian Point Lookout Sandstone, the lower Campanian Menefee Formation, the upper Campanian Fruitland and lower Kirtland Formation (Hunter Wash and De-na-zin members), and the upper Maastrichtian Naashoibito Member, Kirtland Formation. We grouped the teeth into several morphotypes, which are assigned to higher level theropod clades. Principal components analysis and discriminate function analysis were used to test for differences between New Mexican morphotypes and those documented from other geographic areas.

Small teeth of Tyrannosauroidea are recovered from all but the Menefee Formation and many likely represent teeth of juvenile individuals. Two dromaeosaurid morphotypes were identified; one resembles teeth of *Saurornitholestes* or *Acheroraptor* and the other is similar to teeth of *Dromaeosaurus*. Troodontid teeth are rare in the Fruitland and lower Kirtland formations, but are the dominant small theropod tooth in the Naashoibito assemblage. *Richardoestesia* is present in the Fruitland, Hunter Wash, De-na-zin, and Naashoibito members. "*Paronychodon*" is present in the Fruitland and lower Kirtland Formation.

The San Juan Basin contains a diverse record of small theropods. Late Campanian small theropod assemblages differ from approximately co-eval assemblages of the northern Rockies in being less diverse with only rare representatives of troodontids and a *Dromaeosaurus*-like taxon. The late Maashtrichtian assemblage differs in its dominance of a troodontid. These differences provide evidence for provinciality in the late Campanian and the late Maastrichtian of western North America. As in northern latest Cretaceous faunas, there is no indication for a drop in the diversity of small-bodied theropods during the Maastrichtian in New Mexico.

CHRONOSTRATIGRAPHY OF THE CRETACEOUS-PALEOGENE TRANSITION IN THE SAN JUAN BASIN, NEW MEXICO

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The San Juan Basin contains one of the few records of superposed Late Cretaceous and early Paleocene terrestrial faunas and floras. However, the ages and durations of the Upper Cretaceous Naashoibito Member of the Kirtland Formation and the lower Paleocene Ojo Alamo Sandstone and Nacimiento Formation are poorly constrained, thus limiting the ability to correlate their fossil records to the global time scale and hindering efforts to examine such factors as diversity and survivorship of various groups of plants and animals across the K-Pg boundary. The ages of the Naashoibito and the Ojo Alamo are especially contentious and age interpretations range from Campanian to early Paleocene.

Here we present new geochronologic results that combine magnetostratigraphy and $^{40}Ar/^{39}Ar$ dating of detrital sanidine from sedimentary units and sanidine phenocrysts from a volcanic ash to constrain the ages of the Naashoibito Member, the Ojo Alamo Sandstone, and the lower Nacimiento Formation. Coupled detrital sanidine dates, magnetostratigraphy, and mammal biochronology indicate that the Naashoibito correlates to chrons C30n – C29r, suggesting a relatively short depositional history These results indicate that the youngest Cretaceous sedimentary rocks in the San Juan Basin were likely deposited within the last ~400 kyr of the Cretaceous and that there is a significant unconformity in the Kirtland Formation between the Naashoibito Member and the underlying De-Na-Zin Member. Magnetostratigraphy of the Ojo Alamo Sandstone and the Nacimiento Formation at both De-na-zin Wash and near Mesa de Cuba indicate that there is no evidence for diachroneity at the base of the Nacimiento across the basin. Magnetostratigraphy and a $^{40}Ar/^{39}Ar$ sanidine date from an ash within the Nacimiento demonstrate that the middle Puercan Land Mammal Age (Pu2) interval zone began within ~400 kyr of the K-Pg boundary. A probable volcanic ash coincident with the first occurrence of Pu3 mammals tentatively suggests that Pu2 was only ~150 kyr long. These dates and our magnetostratigraphy indicate that the Ojo Alamo was deposited in chron C29r and the lower

HYDROGEOLOGY AND GEOCHEMISTRY OF SPRINGS ALONG SAN PEDRO CREEK, SANDIA PARK, NEW MEXICO

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Several springs flow into San Pedro Creek providing intermittent flow downstream of the springs. San Pedro Creek lies on the east side of the Sandia Mountains in New Mexico and generally flows north from the Sandia Park area towards the Hagan Basin connecting with tributaries to the Rio Grande. The intermittent flows create perennial reaches that tend to disappear into the creek bed along bedrock outcrops.

Springs investigated during this study primarily include San Pedro, Rock, and Cottonwood Springs, and their locations are controlled by local geologic contacts and structures. The San Pedro synclinorium, a plunging fold package dominated by a broad syncline dips towards the south creating bands of outcrops of the major hydrostratigraphic units. Springs tend to discharge along these outcrops at geologic contacts where local aquifers are truncated at the surface by erosion. Springs flow from the primary hydrostratigraphic units such as the combined San Andres Limestone and Glorieta Sandstone aquifer and the Abo Formation aquifer. Water quality data indicates that water emanating from the springs is a mixture of older groundwater and younger recharge.

The Sandia Mountains have a complex geologic history that is reflected in the many rock types and geologic structures that are encountered in the area. The area near San Pedro Creek is dominated by a geologic structure named the San Pedro Synclinorium, which is constrained by the Tijeras and San Antonito faults and contains rocks that have been folded and faulted. Similar geologic structures adjacent to this area are the Tijeras graben and Monte Largo horst. All of the rocks in the study area are highly fractured and jointed due to the local tectonic history.

Rocks from Proterozoic to Quaternary ages are present in the area. Subsurface exploration for water supply development under New Mexico Office of the State Engineer (NMOSE) permit #S-2618 penetrated almost the entire stratigraphic sequence, with drilling terminated at 3,694 feet below ground surface (ft bgs) when intrusive rocks within the Sandia Formation were encountered. Geologic and geochemical characteristics of the major units were analyzed during the exploratory drilling program, and this data was used to help understand the hydrogeology of the springs.

Geochemical data was collected from test zones during exploratory drilling and from springs along San Pedro Creek. Concentrations of major ions and total dissolved solids (TDS) were analyzed along with stable isotopes of oxygen and hydrogen, carbon-14 and tritium. Major ion ratios tend to be similar between spring and groundwater quality samples. Spring water quality tends to be more dilute relative to the groundwater, and tritium data suggests that a younger source of water is mixing with the older groundwater discharging into San Pedro Creek at the springs.

PRELIMINARY ANISOTROPY OF MAGNETIC SUSCEPTIBILITY DATA FROM CLASTIC INJECTITES IN THE DRY CIMARRON VALLEY, UNION COUNTY, NORTHEASTERN NEW MEXICO

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The Dry Cimarron Valley is located in far northeastern New Mexico and trends eastward from Folsom, New Mexico into Oklahoma. The valley walls expose strata of the Upper Triassic Chinle Formation, Middle Jurassic Exeter Sandstone, Middle to Upper Jurassic Morrison Formation, Cretaceous Glencairn Formation and Dakota Group. The northern rim of the valley is capped by young basalt flows from the Raton-Capulin volcanic field. Scattered throughout the Dry Cimarron Valley are numerous clastic injectites that occur as both plugs (cylindrical features) and dikes (planar features) that protrude upwards from the floor of the valley. The clastic injectites occur stratigraphically below the Exeter Sandstone and are within the Chinle Formation. Observations by previous researchers suggest that the majority of material entrained in the injectites originates from the Chinle Formation, particularly the Sheep Pen Sandstone, Sloan Canyon, Travesser, and Baldy Hill Members. However, no detailed studies have previously been conducted to determine the means of emplacement. In this study a series of oriented samples were collected from an exceptionally well exposed plug and associated dikes located along State Highway 325. Due to the high level of sensitivity and precision achievable, anisotropy of magnetic susceptibility (AMS) has long been used as a tool to investigate the flow and deformation dynamics of igneous and sedimentary rock structures. In this study, AMS sampling targeted the undisturbed Chinle strata on either side of the feature, as well as the margins and center of the injectite. The margins of the injectite are continuous well cemented sandstone, whereas the center contains a chaotic mixture of angular clasts of red siltstone and fine grained well cemented sandstone that is surrounded by a poorly indurated mudstone matrix. Capping this injectite is a thin yellow quartz arenite (the Exeter Sandstone?), which uncomfortably overlies the plug. Preliminary AMS data from the Dry Cimarron injectite reveal a geometrical relationship between the bounding walls of the injectite and the measured magnetic anisotropy; we interpret this to reflect viscous flow during the emplacement process. Detailed petrography conducted on five injectite lithofacies and the host rock reveals a complex paragenesis, including precipitation of quartz overgrowths, kaolinite, calcite, and Fe-oxides, as well as grain and cement dissolution. The injectite facies locally display textures indicative of fluidized emplacement, such as subvertical orientations of the long axes of sand grains. Together our AMS and petrographic data show these conduits exhibit an overall subvertical uniaxial extension fabric with an indicated upward flow direction. We interpret this to reflect vertical transport of viscous medium during the emplacement process. These data demonstrate the benefits of combined rock magnetic and petrographic studies when evaluating flow dynamics within clastic injectites.

A HIGH-PRECISION $^{40}Ar/^{39}Ar$ CHRONOLOGY OF LATE-QUATERNARY VOLCANISM IN THE RATON-CLAYTON VOLCANIC FIELD

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High-precision $^{40}Ar/^{39}Ar$ ages of late-Quaternary monogenetic basaltic volcanoes in the Raton-Clayton volcanic field, northeastern New Mexico characterize time-space patterns of eruptions and allow assessment of volcanic hazards. Determining eruption periodicity and durations of eruptive cycles are fundamental for volcanic hazard assessment. A previous $^{40}Ar/^{39}Ar$ study concluded that volcanism in the field began at ~9 Ma and ended at ~56 ka with the eruption of the well-known Capulin volcano. However, this chronology is not sufficiently precise or complete for a comprehensive volcanic hazard assessment. High-precision ages for this study were determined using a low-volume, high-sensitivity, multi-collector ARGUS VI mass spectrometer, which yields about an order of magnitude more precise isotopic measurements compared to older generation, single-detector mass spectrometers. New $^{40}Ar/^{39}Ar$ ages indicate 1) sparse volcanic activity between 200 and 500 ka, 2) eruptions from two centers at ~100 ka, and 3) a significant pulse of volcanism between ~32 and 55 ka including as many as three eruptions that are younger than Capulin volcano. Eruptions prior to 200 ka include the 426 ± 8 ka Las Maetas South center and 240 ± 7 ka Horseshoe Crater, which are both located to the south of Capulin volcano. The Trinchera Pass volcano, located near the New Mexico-Colorado border, erupted at 113 ± 7 ka. Volcanism shifted back to the southern part of the field where numerous lava flows erupted from The Crater cinder cone. A stratigraphically low lava flow at The Crater yielded an age of 97 ± 3 ka, whereas a lava flow on the flanks of The Crater yielded an indistinguishable age of 103 ± 5 ka indicating the volcano is monogenetic. Finally, volcanic activity migrated to the vicinity of Capulin volcano. Our new age for Capulin volcano is 55 ± 2 ka. This new age is indistinguishable from, but more precise than the previously determined age of 56 ± 8 ka. Baby Capulin is located ~4 km north of Capulin volcano. Multiple analyses of lavas from this center yielded an age of 46 ± 4 ka. East of Baby Capulin is Twin Mountain volcano, which yielded an age of 40 ± 4 ka. The youngest dated center in the field is Purvine Hills, three east-west aligned vents likely representing a fissure eruption. The $^{40}Ar/^{39}Ar$ age of Purvine Hills is 32 ± 5 ka. Electron microprobe analyses of spinel inclusions in olivine were conducted to assess the source of the 46 ± 15 ka Folsom Falls lava flow. Subtle variation in Cr_2O_3 and MgO/FeO ratios suggest that the Folsom Falls lava is the distal flow of the Baby Capulin lava flow. Ages and associated uncertainties indicate recurrence rates of 0 ka to as much as 17 ka for this youngest phase of volcanism in the Raton-Clayton field. New $^{40}Ar/^{39}Ar$ ages demonstrate the unprecedented capabilities of the ARGUS VI mass spectrometer, which is currently being used to assess temporal-spatial patterns at all late Quaternary volcanic centers in the Rio Grande rift and along the Jemez lineament.