Abstracts

New Mexico Geological Society spring meeting

The New Mexico Geological Society annual spring meeting was held on April 18, 2008, at Best Western Convention Center, Socorro. Following are the abstracts from all sessions given at that meeting.

KEYNOTE

IS A FEW BILLION ACRE-FEET OF STORED GROUND WATER REALLY A RESOURCE?, *J. W. Shomaker*, John Shomaker & Associates, Albuquerque, New Mexico 87106

Many river-connected ground water basins store large volumes of water that can't be pumped and used because the resulting depletion of the flow of the river would impair the rights of downstream users. The Albuquerque–Belen Basin, for example, stores several hundred million acre-feet, which might be compared with the recent (Year 2000) combined consumptive use of 184,000 acre-feet in Sandoval, Bernalillo, and Valencia Counties, but the Rio Grande is already over-appropriated, and an increase in pumping would cause still more depletion of the stream. The Española and Lower Rio Grande Basins store hundreds of millions of acre-feet more. If the system is too large for channel-lining to be practical, to isolate the river from the ground water system, the stored ground water must simply remain in place.

Another approach would be to pump the nonrenewable ground water, put to beneficial use only the portion that actually comes from storage, and return the balance to the stream. As the cones of depression expand and eventually reach equilibrium, the entire amount pumped would be at the expense of streamflow—but pumping and delivery to the stream must continue forever so as to prevent the natural system from replacing the volume withdrawn from storage. Although it seems implausible, this situation is theoretically sustainable if the revenue derived from sale of the stored water has established a perpetual fund to support the continued pumping. One hypothetical system in the Rio Grande valley could provide a total of about 6.8 million acre-feet for municipal use (with 50% return flow) over 100 yrs, at a cost less than large-scale desalination. A very reliable understanding of the ground water regime, and the threshold of subsidence problems due to excessive drawdown, would be vital. Public-policy implications include allowing growth to become dependent on a continually shrinking supply, responsibility for the perpetual pumping, and commitment of future energy resources.

INVITED SPEAKERS

THE SAN LUIS BASIN OF THE NORTHERN RIO GRANDE RIFT, *P. W. Bauer*, bauer@nmt.edu, New Mexico Bureau of Geology and Mineral Resources, New Mexico Institute of Mining and Technology, Socorro, New Mexico 87801

The San Luis Basin (SLB) is the northernmost large basin of the Rio Grande rift. It extends about 240 km from Velarde, New Mexico, to Poncha Pass, Colorado, encompassing the San Luis Valley to the north and the Taos Plateau to the south. The basin is bounded on the east by the Sangre de Cristo Mountains, on the west by the Brazos uplift and San Juan Mountains, and on the south by the Picuris Mountains. Ranging from 30 to 70 km wide, with elevations between about 7,000 and 8,000 ft, the basin is said to be the world's largest high-elevation valley. It is nearly the size of the state of Connecticut and averages less than seven people per square mile. The Rio Grande originates in the San Juan Mountains, flows through the valley to Alamosa, runs south through a gap in the San Luis Hills, and into New Mexico where it has carved the Rio Grande gorge.

The SLB is east-tilted, with about 8 km of Neogene throw along the normal Sangre de Cristo fault, and with a complex hinge zone along the western border. In the New Mexican portion of the basin, a deep north-south graben (the Taos graben) exists along the Sangre de Cristo fault. The deepest part of the graben is west of Taos Pueblo, where the depth to Precambrian rocks is estimated to be >5,000 m. The west-bounding fault of the Taos graben, known as the Gorge fault, approximately coincides with the Rio Grande gorge. West of the gorge, a bedrock bench rises gently to the topographic basin boundary along the Tusas Mountains. To the north, the bench becomes a complex, intra-rift horst with pre-rift, Oligocene volcanic rocks exposed in the middle of the rift at the San Luis Hills of southern Colorado. The 65-km-long, northeast-striking Embudo fault is a transfer (or accommodation) zone that forms the complex structural boundary that absorbs the differential extension between the east-tilted SLB and the west-tilted Española Basin.

The southern part of the basin is a physiographically and geologically unique terrain known as the Taos Plateau. The Pliocene to Pleistocene Taos Plateau volcanic field is the largest (7,000 sq km) and perhaps most compositionally diverse volcanic field in the rift, with at least 35 discrete vents that range from tholeiitic basalt to rhyolite, and that form vent morphologies including shield volcanoes, cinder cones, and volcanic domes. The plateau surface shows only minor dissection, with the Rio Grande and its major tributaries confined to deep canyons.

The SLB is host to a variety of recent and ongoing geological work. Through the STATEMAP program, the NMBGMR has mapped all of the 7.5-min quads in the southern SLB. The largest ongoing project is a USGS program designed to assess the influence of geology on the availability of ground water, natural resources, and hazards in the central SLB. As part of this study, much of the basin was flown for a high-resolution aeromagnetic survey. Other recent and ongoing NMBGMR projects include: a series of detailed hydrogeologic assessments of high-growth areas in the Taos region; an inventory and geochemical study of the springs in the Rio Grande gorge; a paleoseismic trenching study of the southern Sangre de Cristo fault near Taos; and a study of the geology, hydrogeology, and hydrogeochemistry of surface water/ground water interactions along the Rio Grande in northern Taos County. The Taos Soil & Water Conservation District has inventoried water wells and mapped the ground water and water quality of the county. Over many years, Glorieta Geoscience, Inc., has investigated the hydrogeology, aquifer characteristics, and hydrogeochemistry of the Taos region.

EVOLVING GEOLOGIC UNDERSTANDING OF THE ESPAÑOLA BASIN, RIO GRANDE RIFT, NORTHERN NEW MEXICO, *G. A. Smith*, gsmith@unm.edu, Department of Earth and Planetary Sciences, University of New Mexico, Albuquerque, New Mexico 87131

The Española Basin is central to studies of the Rio Grande rift because it is home to the type Santa Fe Group—superb badland exposures of rift-basin fill rich in vertebrate faunas and datable ash beds. New 1:24,000-scale geologic maps (mostly NMBGMR supported by USGS-STATEMAP), aeromagnetic data (USGS), and subsurface stratigraphic studies of the Pajarito Plateau (LANL) have enhanced geologic understanding over the last decade. Stratigraphic studies and lithofacies mapping by Dan Koning build upon earlier interpretations by Ray Ingersoll to show that three primary sediment sources filled the basin: erosion of granitic basement and Paleozoic rocks of the Santa Fe Range on the east, recycling of volcaniclastic debris along with quartzite-rich basement detritus derived from the north, and recycling of volcaniclastic debris along with Paleozoic sedimentary detritus that entered the basin from northeast. This latter sediment pathway may relate to an ancestral Rio Embudo with headwaters far to the east of the modern river, as suggested by upper Miocene basalt flows that probably entered the basin from the Ocate volcanic field. The Santa Fe River also had a larger watershed in the past that included the modern upper Pecos Valley. This larger drainage produced coarse-grained, hydrologically important channel deposits rich in Paleozoic sedimentary detritus and quartzite that covered a broad area of the southern basin during the Miocene. Beheading of the earlier Santa Fe River basin may have resulted from rise of the Santa Fe Range as a ruptured hanging-wall hinge zone uplift that paradoxically defines higher elevations than the footwall region along the western side of the Española Basin. Research in two areas implies that basin subsidence was underway by Oligocene to early Miocene. Near Santa Fe, volcaniclastic strata of the Bishop's Lodge Member of the Tesuque Formation correlate to the Espinaso Formation and include 30 Ma tephra. These deposits overlie ~400 m of conglomerate derived from Paleozoic and Precambrian rocks and deposited on basement formerly denuded during Laramide uplift. These relationships indicate Oligocene foundering of the earlier uplift. Within the Abiquiu embayment in the northwest part of the basin, pre-25 Ma strata of the lowermost Santa Fe Group thin westward across a staircase of east-facing faults to the rift margin.

A GEOLOGIC OUTLINE OF THE ALBUQUERQUE BASIN, *S. D. Connell*, connell@gis.

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The Albuquerque Basin of the Rio Grande rift was the subject of intensive multiagency geologic and hydrogeologic study beginning in the 1990s. A focus of geologic study was on new mapping to better describe and understand the Santa Fe Group basin-fill aquifer system, which currently provides much of the region's supply of water. Results of these geologic studies led to the creation of a refined stratigraphy that incorporated subsurface data and improved age control. This work illustrated how the structural geometry and geomorphic evolution of this basin influenced the spatial distribution of rock types and faults and explained why parts of this basin possess more productive water-supply wells than others. The Albuquerque Basin is segmented into smaller complexly faulted half-graben subbasins by strain accommodation zones. Rifting began in late Oligocene time with the creation of segmented, internally drained sub-basins that were dominated by fluviolacustrine and eolian sediments. By late Miocene time, sandier fluvially dominated extrabasinal sediments associated with the ancestral Rio Grande reached the northern part of the basin and ended in playa lakes at the southern end. By early Pliocene time, this axial river flowed through the basin and into southern New Mexico. By Plio–Pleistocene time, the axial-river load had coarsened and migrated toward the present position of the Rio Grande valley, where it incised to form a continuous river valley. In the Albuquerque–Rio Rancho area, the western basin margin is structurally high, and potable ground water is mostly derived from consolidated and calcite-cemented Miocene sediments. This structurally high western flank also provides shallower targets for petroleum development in the subjacent Mesozoic strata. The structurally lower eastern part of the basin under Albuquerque contains younger, coarser, and thicker Plio–Pleistocene strata that produce some of the largest yields and generally higher quality ground water in the region. An unconformity locally aids in differentiating between the less productive Miocene and more productive Plio–Pleistocene deposits. As potable water sources become scarce, abundant brackish-water resources may become attractive production targets for desalination along the structurally higher northwestern flanks of the basin. With each new generation of geologic mapping, our understanding about the geologic history and distribution of earth resources improves considerably.

SEDIMENTOLOGY AND PROVENANCE OF BASIN-FILL STRATA AS A GUIDE TO FAULT EVOLUTION, SOUTHERN RIO GRANDE RIFT, *G. H. Mack*, and *W. R. Seager*, Department of Geological Sciences, New Mexico State University, Las Cruces, New Mexico 88003

The southern Rio Grande rift constitutes a broad (150 km) region of mid-late Cenozoic crustal extension that is characterized by 20 fault blocks. The history of individual range-boundary faults can be deduced by using the sedimentology and provenance of strata deposited in complementary basins. This approach is especially applicable to a 100 km stretch of the southern rift from Truth or Consequences to Las Cruces, where basin-fill strata ranging in age from late Oligocene to Pleistocene are widely exposed.

Deposition of the Hayner Ranch Formation (upper Oligocene–mid Miocene) took place in a north- to northeast-tilted half graben whose footwall was the Caballo Mountains. By the end of deposition of the Hayner Ranch Formation, stratigraphic separation on the Caballo fault system had reached ~1,615 m. During deposition of the upper Miocene Rincon Valley Formation, an additional 850 m of stratigraphic separation occurred on the Caballo fault block and the Sierra de las Uvas began to rise, the latter creating a west-tilted half graben with ~550 m of stratigraphic separation on its boundary fault. The two late Miocene basins were linked by a gypsum-precipitating playa lake.

Deposition of the Camp Rice and Palomas Formations (Pliocene–lower Pleistocene) was accommodated by continued movement along the faults bordering the Caballo Mountains (760 m stratigraphic separation) and Sierra de las Uvas (100 m stratigraphic separation), as well as by new faults that uplifted the Red Hills, Animas Mountains, Rincon Hills, northwestern Sierra de las Uvas, Cedar Hills, San Diego Mountain, and Robledo Mountains. During this time the ancestral Rio Grande flowed through six basins, with the location and width of the floodplain largely controlled by basin symmetry. Periodic kilometer-scale shifting of the axial river toward the Caballo footwall was a response to active faulting and basin tilting. Following deposition of the Camp Rice and Palomas Formations (post-0.8 Ma), many pre-existing and new faults experienced activity, including 40 m of offset on the Caballo fault.

SESSION 1—RIO GRANDE RIFT, SAN LUIS AND ESPAÑOLA BASINS

STRUCTURAL CONTROLS ON GROUND WATER FLOW AND RECHARGE INTO THE SOUTHERN SAN LUIS BASIN NEAR TAOS, NEW MEXICO, *P. Drakos, J. Lazarus, J. Riesterer*, Glorieta Geoscience Inc., P.O. Box 5727, Santa Fe, New Mexico 87502; *K. Sims*, Department of Geology and Geophysics, Woods Hole Oceanographic Institution, Woods Hole, Massachusetts 02543; and *M. Hodgins*, Glorieta Geoscience Inc., P.O. Box 5727, Santa Fe, New Mexico 87502

Subsurface lithologic and geophysical data from a series of municipal, exploratory, subdivision, and domestic wells are used to delineate variations in thickness and extent of Tertiary through Quaternary sediments and Pliocene basalt flows and interbedded fluvial sequences in the southern San Luis Basin near Taos, New Mexico. These data are also utilized to help constrain the location of buried faults. Two deep wells drilled in 2007 are used to refine previously published stratigraphic analyses of basin-fill deposits. Analyses of long-term pumping tests conducted in proximity to faults are used to evaluate the effect of faults on ground water flow in shallow and deep basin-fill aquifers. Selected wells and surface water sources were sampled and analyzed for major anions and cations, trace metals, $^{87}Sr/^{86}Sr$, ^{3}H, $\delta^{2}H$, and $\delta^{18}O$. Tritium results indicate that recharge to the shallow aquifer occurs on a time scale of <5–10 yrs, but that recharge to some deep alluvial wells and wells completed into sediments interbedded with the Servilleta basalts occurs on a time scale of >50 yrs. Recharge into the mountain front fractured bedrock aquifers occurs on time scales ranging from <5–10 yrs to >50 yrs. $\delta^{2}H$ and $\delta^{18}O$ data suggest that some deep basin-fill aquifer wells have received higher-elevation or older (Pleistocene?) recharge, whereas other deep wells have received lower-elevation or modern/Holocene recharge. $^{87}Sr/^{86}Sr$ varies from 0.7074 to 0.7156, indicating water-rock interaction with variable source rocks. Because these waters have relatively enriched $^{87}Sr/^{86}Sr$ it is likely that the Pennsylvanian carbonates and granitic basement rocks have contributed significantly to their Sr isotopic compositions. Although faults typically do not act as impermeable boundaries in the shallow alluvial aquifer, the Seco fault and several of the Los Cordovas faults act as impermeable boundaries in the Servilleta Formation and in the deep basin-fill aquifer. However, other Los Cordovas faults do not act as significant impermeable boundaries in the deep aquifer, suggesting variable cementation along fault planes at depth.

GROUND WATER HYDROLOGY AND GEOCHEMISTRY OF TAOS COUNTY, *A. L. Benson*, benson1@newmex.com, and *R. Gervason*, rongeo45@gmail.com, Taos Soil and Water Conservation District

This study was undertaken as a project of the Taos Soil and Water Conservation District, to begin the process of addressing concerns about ground water resources in Taos County. This is in a geologically complex area within the San Luis rift basin. To provide baseline data for Taos County, nearly 2,000 water wells have been accurately located using GPS. Water table elevation maps have been prepared and a depth-to-water map prepared for laymen. Depth-to-water varies from less than 100 ft along perennial streams along the Sangre de Cristo Mountain front to over 1,000 ft in western Taos County. Direction of ground water flows can be seen on the water table elevation maps, and recharge sources can be implied for many areas from these maps. Deeper wells below 500 ft show effects of a downward pressure gradient and were not used for the water table maps.

Structure maps on the Servilleta basalt were made and used in conjunction with aeromagnetic data to map the numerous faults within the study area. Water table differences are seen across faults that impact aquifers below depths of 200 ft. Upward pressure gradients and warm waters are frequently observed along faults. About 500 wells were plotted for major cations and anions and trace inorganics. Contoured maps were prepared on 19 selected constituents, including TDS, HCO_3, Br, Cl, F, N, SO_4, Ca, K, Mg, Na, As, Ba, Cr, Pb, Si, Sr, U, and Zn. High values exceeding EPA drinking standards were mapped mainly along fault traces. Hydrochemical zones are mapped across the county reflecting the geology of recharge source areas and age of ground water.

The eastern part of the rift basin is gifted with perennial recharge from the mountain front into a large clastic section that serves as a thick aquifer, which provides drinking water for the majority of the population of Taos County. Local ground water problems include a slight water table drop adjacent to streams during drought periods, rapid draining through fractured dacite lavas, low production rates of fine-grained and volcanoclastic reservoirs in western Taos County, and cementation of the Picuris Formation aquifer in southern Taos County.

STRUCTURAL EVOLUTION OF THE EASTERN ESPAÑOLA BASIN, RIO GRANDE RIFT, NORTH-CENTRAL NEW MEXICO, *D. J. Koning*, dkoning@nmt.edu, New Mexico Bureau of Geology and Mineral Resources, New Mexico Institute of Mining and Technology, Socorro, New Mexico 87801; *S. D. Connell*, New Mexico Bureau of Geology and Mineral Resources, New Mexico Institute of Mining and Technology, Albuquerque Office, Albuquerque, New Mexico 87106; *J. Slate*, U.S. Geological Survey, P.O. Box 25046, Federal Center, MS 913, Lakewood, Colorado 80225; *E. Wan*, U.S. Geological Survey, 345 Middlefield Road, MS 975, Menlo Park, California 94025; *J. F. Ferguson*, Program in Geosciences, University of Texas at Dallas, P.O. Box 30688, Richardson, Texas 75083-0688; *V. J. S. Grauch*, U.S. Geological Survey, Box 25046, Federal Center, MS 964, Denver, Colorado 80225; *G. WoldeGabriel*, Earth and Environmental Sciences Division, P.O. Box 1663, Los Alamos National Laboratory, Los Alamos, New Mexico 87545; *L. Peters, W. C. McIntosh, N. Dunbar,* New Mexico Bureau of Geology and Mineral Resources, New Mexico Institute of Mining and Technology, Socorro, New Mexico 87801; *D. Broxton,* and *W. S. Baldridge*, Earth and Environmental Sciences Division, P.O. Box 1663, Los Alamos National Laboratory, Los Alamos, New Mexico 87545

We interpret the timing of basin tilting as well as deformation along specific structures in the eastern Española Basin (EEB). The EEB has a half-graben geometry north of Santa Fe, with beds generally tilted 2–10° W toward a central fault system (CFS). The CFS includes the northeast-striking Embudo fault system and the Santa Clara fault (SCF) to the north, collectively acting as a rift transfer structure, and the north-striking, east-down Pajarito fault (PF) to the south. Between the PF and SCF is a 6-km-long zone consisting of several west-down faults. A series of aligned faults and folds comprise two major north-striking structures east of the CFS. Santa Fe Group basin fill attains a general thickness of 1–3 km in the EEB. However, basin fill thickens to 3–4 km in structural lows related to localized subsidence immediately adjacent to three faults of the CFS. An unconformity recognized north of Santa Fe is bracketed between 25–30 Ma.

Stratal tilt data from relatively unfaulted areas indicate an episode of high-tilt rates between 16–10 Ma. Significant deformation continued along the aforementioned two major structures east of the CFS in the late Miocene–Pliocene. Earlier tilting along these structures is suggested by seismic reflection data and by angular relations across the 25–30 Ma unconformity (at least locally). Pronounced subsidence occurred in the structural lows adjacent to the PF and SCF in the late Miocene–Pliocene.

We interpret the timing of vertical displacement along the PF and SCF by comparing thickness changes and vertical offsets of faulted stratigraphic intervals in the Santa Fe Group. These indicate high throw rates along the SCF and PF, and faults branching off of these structures, between 13–10 Ma. Approximately 430–500 m of stratigraphic separation of post-10 Ma Chamita Formation strata and lesser vertical offset of the Pliocene-age Puyé Formation indicate that significant vertical motion along the SCF occurred after 10 Ma.

We infer that lateral motion along the SCF commenced by 9–12 Ma and peaked at 6–4 Ma using the Chamita syncline, which we assume is related to transpression created by the right-step between the EF and SC. Cross sections suggest thickness changes across the Chamita syncline for post-12 Ma strata. A pronounced angular unconformity on the north limb indicates strong folding at 6–4 Ma.

STRUCTURAL AND STRATIGRAPHIC IMPLICATIONS OF OIL AND GAS DRILLING AND SEISMIC EXPLORATION IN THE SANTA FE EMBAYMENT OF THE ESPAÑOLA BASIN, NORTH-CENTRAL NEW MEXICO, *B. A. Black*, Black Oil Co., 206 W. 38th Street, Farmington, New Mexico 87401; and *W. K. Dirks*, Tecton Energy LLC, 3000 Wilcrest Suite 300, Houston, Texas 77042

Ninety-four (94) years of oil and gas exploration has taken place in the Santa Fe embayment of the Española Basin. The last 34 yrs of this exploration has documented the contrasting effects of Laramide compression and later Tertiary extensional tectonics in the southern portions of the area.

As many as three separate thrust plates have been drilled in the area. The well control combined with the available seismic lines demonstrates the presence of both pre-rift thrusting and expected later normal faulting associated with the opening of the Rio Grande rift. Possible flower structures associated with lateral movements along the northeast extension of the Tijeras shear in this area are also possible.

In 1985 the first oil production from the Rio Grande rift was marketed from the Santa Fe embayment. It would be 26 yrs before this subeconomic discovery (at $8.00 a barrel) would eventually prove to be an economic success (at $50+ a barrel). The re-completion of this well and the solving of the subsurface geologic story are more than three and a half decades in the making. A recent 6-month moratorium declared by the governor on oil and gas drilling in Santa Fe County will slow, or perhaps even terminate, our continuing ability to learn the details of the subsurface geology of this unique area.

The commercially successful Tecton Black-Ferrill #1, and subsequent activities, has begun to open a new oil and gas province in the Rio Grande rift. The recent exploration activities and production of high gravity oil suggests that million-barrel oil accumulations are potentially present within the downthrown areas of the rift.

Abundant source rock, a favorable history of maturity, and extensive reservoir systems are present in the Cretaceous rocks of the Santa Fe embayment. Structural and stratigraphic complexities will account for a portion of the trapped oil and gas, and fractured Niobrara shale has large potential for oil and gas production over numerous sections in the southern part of the Española Basin.

STRATIGRAPHY AND TECTONIC IMPLICATIONS OF OLIGOCENE TO EARLY MIOCENE SEDIMENTATION IN THE JEMEZ MOUNTAINS, NORTH-CENTRAL NEW MEXICO, *S. A. Kelley*, sakelley@ix.netcom.com, New Mexico Bureau of Geology and Mineral Resources, New Mexico Institute of Mining and Technology, Socorro, New Mexico 87801; *K. Kempter*, 2623 Via Caballero del Norte, Santa Fe, New Mexico 87505; *F. Maldonado*, U.S. Geological Survey, MS 980, Denver Federal Center, Denver, Colorado 80225; *G. Smith*, Department of Earth and Planetary Sciences, University of New Mexico, Albuquerque, New Mexico 87131; *S. D. Connell,* and *D. J. Koning*, New Mexico Bureau of Geology and Mineral Resources, New Mexico Institute of Mining and Technology, Socorro, New Mexico 87801

The Abiquiu Formation has traditionally been informally divided into three units: lower, Pedernal chert, and upper. During the course of recent 1:24,000 scale mapping in the Jemez Mountains, we came to recognize that two lithologically distinct, geographically restricted successions of conglomerate comprise the "lower Abiquiu" and that the provenance of these coarse sediments is quite different from the provenance of strata assigned to the "upper Abiquiu." Maldonado and Kelley (in prep.) have suggested restricting the name Abiquiu Formation to "upper Abiquiu" strata and applying the name Ritito Conglomerate to "lower Abiquiu"conglomerate exposed near the village of Abiquiu. Here, we propose the name Gilman Conglomerate for conglomerate exposed near the village of Gilman in the southwest Jemez Mountains. The basement-derived Ritito Conglomerate is exposed along the southeast flank of the Tusas Mountains, beneath the northwest Jemez Mountains as far south as the northwest corner of the Valles caldera, and as far west as San Pedro Parks in the Sierra Nacimiento. The volcaniclastic Gilman Conglomerate is present near the villages of San Ysidro, Jemez Springs, and Gilman along the Jemez fault zone. The restricted Abiquiu Formation covers a broad region of north-central New Mexico, with exposures as far south as the southwest Jemez Mountains. Clasts from the Latir volcanic field are common in the Abiquiu Formation in the northern Jemez Mountains but are absent in the southwest Jemez Mountains. Localized basalt flows and volcaniclastic sedimentation that are temporally equivalent to late Abiquiu deposition elsewhere in the Jemez Mountains are preserved in the southeast Jemez Mountains on St. Peters Dome. The Pedernal chert is 1–2 m thick on Cerro Pedernal and Encino Point and occurs in the uppermost part of the Ritito Conglomerate. The chert is absent east of the Cañones fault zone. Multiple layers of chert occur in the restricted Abiquiu Formation on the west side of the Coyote fault zone, and thin stringers of chert are present in the Abiquiu Formation in the southwest Jemez Mountains.

The distribution of the conglomeratic units indicates the presence of two distinct sub-basins in the vicinity of the Jemez Mountains early in Oligocene time. Later widespread volcaniclastic sedimentation sourced from the Latir volcanic field covered the region, while localized volcanism and sedimentation occurred in the southeast Jemez Mountains. Finally, silica-enriched ground waters deposited chert below the basal contact and within the Abiquiu Formation.

INFLUENCE OF BASEMENT STRUCTURE ON SHALLOW AQUIFER GEOCHEMISTRY IN THE RIO GRANDE RIFT, NORTHERN NEW MEXICO—EXAMPLES FROM THE SANTA FE AND PEÑASCO EMBAYMENTS OF THE ESPAÑOLA BASIN, *P. S. Johnson*, peggy@gis.nmt.edu, New Mexico Bureau of Geology and Mineral Resources, New Mexico Institute of Mining and Technology, Socorro, New Mexico 87801; *V. J. S. Grauch*, U.S. Geological Survey, Geologic Division, Denver, Colorado 80225; *P. W. Bauer, D. J. Koning,* and *S. W. Timmons*, New Mexico Bureau of Geology and Mineral Resources, New Mexico Institute of Mining and Technology, Socorro, New Mexico 87801

The west-tilted half graben of the eastern Española Basin is structurally and topographically high along the base of the southern Sangre de Cristo Mountains, where Precambrian basement lies at shallow depths beneath Santa Fe Group rift sediments that form the region's primary aquifers. At the southern end of the basin, geophysical data indicate a shallow platform bounded on its northern side by a north-down, arcuate flexure herein named the Rancho Viejo hinge zone. Both the platform and the hinge zone have been folded into a north-plunging syncline. Whereas the Santa Fe Group is 250 ft or less across much of the Santa Fe platform, the upper surface of Oligocene-age volcanic and volcaniclastic strata, which forms the base of the Santa Fe Group aquifer, appears faulted and irregular, with as much as 650 ft of Santa Fe Group filling local paleovalleys eroded on the surface. The Oligocene surface is deformed dramatically across the Rancho Viejo hinge zone, where depth (and thickness of Ancha and Tesuque Formations) increases from 500 to 2,000 ft. Northwest of Santa Fe, north-striking faults in the Barrancos structure zone uplift blocks of Oligocene volcanic rocks, thinning the Santa Fe Group to about 3,000 ft. These basement structures produce a relatively thin Santa Fe Group aquifer in the Santa Fe embayment and have brought Precambrian and Oligocene rocks upward into range of shallow domestic and municipal water wells. Upward movement of deep, sodium- and arsenic-rich (up to 54 µg/L) ground water into the shallow aquifer near Santa Fe may be facilitated by basement faults and flexure-related fracturing of Oligocene volcanic rocks in the Rancho Viejo hinge zone.

At the northern end of the basin, geologic mapping defines the Peñasco embayment as a bedrock low between the Picuris Mountains to the north and the Sangre de Cristo Mountains to the south. The Dixon Member (Tesuque Formation) and Picuris Formation fill the embayment to depths ranging from a few tens to several hundred feet, and form the valley's major aquifers. Sets of northeast-striking faults associated with the Picuris–Pecos fault system form horst and graben structures in the embayment that are oriented perpendicular to directions of regional ground water and surface water flow. The Peñasco horst, a major upthrown block of Precambrian crystalline rock, lies as much as 300 ft below land surface at Chamisal to as little as 30 ft below the Rio Santa Barbara. Locally elevated concentrations of naturally occurring uranium, arsenic, and fluoride are associated with the Peñasco horst, the Picuris–Pecos fault system, and/or tuffaceous sediments in the Picuris Formation. Anomalously high TDS, chloride, chloride/bromide ratios, and silica are also measured in shallow wells near horst-bounding faults.

SESSION 2—STRATIGRAPHY, STRUCTURE, AND PALEONTOLOGY

HETEROGENEOUS STRAIN IN A "DRAG" FOLD ADJACENT TO THE PICURIS–PECOS FAULT IN NORTHERN NEW MEXICO—PRELIMINARY RESULTS

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In the Picuris Mountains of northern New Mexico, the east-trending, Proterozoic north-vergent Hondo syncline is refolded adjacent the Picuris–Pecos fault (PPf) by a southwest-plunging synform that is <1.5 km wide east-west and ~8 km long north-south. The relationship between the PPf and the refold has not been studied systematically. Miller et al. (1963) interpreted the refold as a ductile dextral drag fold along the PPf, but it also may be due to PPf propagation or be an older, unrelated structure. Controversy over earliest PPf motion(s) continues: Precambrian and ductile (e.g., Miller et al. 1963; Fankhauser and Erslev 2004; Wawrzyniec et al. 2007) versus Phanerozoic and brittle (e.g., Ancestral Rockies or Laramide; Karlstrom and Daniel 1993; Daniel et al. 1995; Cather et al. 2006). The focus of this study is to characterize the deformation due to folding and determine if there is a genetic relationship with the PPf.

Twenty-four quartzite samples from the south- to southwest-dipping Proterozoic Ortega and Rinconada Formations in the south limb of the Hondo syncline were collected along strike through the refold, up to ~2 km from the PPf. Thin sections were cut in horizontal planes in order to document fabrics related to horizontal shear couples or vertical-axis rotations. A quartz microstructural analysis was done to test for a ductile strain gradient within the refold or with distance from the PPf; quartzite samples collected by Bauer (1987), mainly from the north limb of the Hondo syncline, provide ductile fabrics west of the refold for comparison. Those samples show mainly annealed foam texture, presumably relict from 1.4 Ga heating (Bauer 1987). Minor faults and fractures were also measured and characterized along the same transects in order to relate brittle deformation to the folding.

Heterogeneous ductile strain in the refold overprints the foam texture and implies a Proterozoic (post-1.4 Ga) age for the refold, which may predate the PPf itself. Fabrics include mainly northeast-southwest elongate grains (northwest-southeast horizontal shortening) with undulose extinction, sutured grain boundaries, and subgrain development, suggesting low-T deformation. The highest strain is in the refold hinge zone, but high-strain samples also come from both limbs ~1 km west and southeast of the hinge. The deflection of the Hondo syncline can be explained by either east-side-up or dextral shear in a north-striking zone. However, such shear fails to explain the apparent lack of a systematic strain gradient approaching the PPf or the northwest-southeast grain-scale shortening direction, which implies sinistral shear on the PPf. Possibly, grain-scale fabrics were controlled by specifics of the fold mechanisms (e.g., flexural slip) rather than the regional tectonic strain patterns. Preliminary field and petrographic data suggest that brittle structures are also concentrated in the hinge zone of the refold. These structures may be related to the brittle-ductile folding event, or may be much younger.

GENESIS OF FAULT BRECCIA AT DEER CREEK—IMPLICATIONS FOR THE SLIP HISTORY OF THE PICURIS–PECOS FAULT

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Spectacular fault breccia as much as 250 m wide is exposed at Deer Creek along the Picuris–Pecos fault (PPf), ~18 km southeast of Santa Fe. There, the PPf juxtaposes Middle Pennsylvanian–Permian strata (Alamitos Formation and Sangre de Cristo Formation) with Proterozoic granite-gneiss on the west. In addition to the ~38 km dextral separation documented elsewhere along the fault, the PPf at Deer Creek shows stratigraphic evidence for ~300 m of east-down separation. The breccia consists of two zones: (1) An eastern zone, 10–50 m wide, directly west of the PPf, within which clasts of Proterozoic gneiss exhibit diverse foliation orientations within individual outcrops. Also in this zone are sparse, meter-scale blocks of indurated Mississippian–Pennsylvanian sedimentary rocks and significant fine-grained cataclasite. We interpret this breccia zone as recording dilation and shear in a high-strain zone adjacent to the PPf. (2) A western zone as much as 200 m wide has low dispersion of foliation orientations within individual outcrops. This zone exhibits relatively minor fine-grained cataclasite, is strongly indurated by red jasperoid, and locally is cut by less-brecciated pods of Mississippian carbonate (probable fissure fills) and Pennsylvanian–Permian arkosic sandstone. We interpret this breccia zone to have formed by weak dilational strain. In both breccia zones, the average orientation of foliation is rotated ~20–30° counterclockwise relative to that in undeformed gneiss to the west. This rotation occurred before widespread Permian remagnetization in the area, as no significant vertical-axis rotation has occurred since then (Wawrzyniec et al. 2007).

The inferred sequence of geologic events was: (1) Pre-Permian (probably Proterozoic, based on regional deformation patterns) sinistral shear caused counterclockwise rotation of foliation near the fault. (2) Pre-Middle Mississippian (early Ancestral Rocky Mountains orogeny (ARM) or older) dilation and brecciation. (3) Opening and filling of fissures during Middle Mississippian carbonate sedimentation and karst development. (Local post-brecciation, pre-jasperoid chlorite cement is also present, but its age relationship with the fissure fills is uncertain). (4) Late ARM injection of unlithified arkosic sand from the Alamitos Formation or Sangre de Cristo Formation into unindurated fault breccia. (5) Late ARM or Laramide deformation (sans vertical-axis rotation) caused mixing of clasts of lithified upper Paleozoic strata into breccias along the PPf, folding and faulting in Paleozoic strata east of the PPf, and enhanced the permeability in breccias. (6) A major Oligocene hydrothermal system was localized by the high-permeability fault breccias, causing jasperoid cementation (microquartz after chalcedony) and reheating (>110° C) that reset regional Laramide apatite fission-track cooling ages to 32–26 Ma near Deer Creek. (7) Development of numerous minor faults that cut jasperoid-cemented breccias, presumably during Neogene rifting. In contrast to recently published interpretations, geological relationships at Deer Creek do not require major Proterozoic dextral slip (and instead suggest some Proterozoic sinistral slip), nor do they disallow major ARM or Laramide dextral slip on the PPf.

TRIASSIC STRATIGRAPHY SOUTH OF LAMY, NEW MEXICO

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The Triassic stratigraphy around Lamy, Santa Fe County, New Mexico, has been relatively understudied compared to contemporaneous sections in north-central (Rio Arriba County) and east-central New Mexico (Quay County). A composite section is ~507 m thick and consists of Permian (Artesia Group), Middle Triassic (Moenkopi Group), and Upper Triassic strata (Santa Rosa, Garita Creek, Trujillo, Petrified Forest, and Rock Point Formations). The Artesia Group (18–25 m) overlies limestones of the San Andres Formation and consists of interbedded sandy mudstones and crossbedded sandstones with rare gypsiferous beds. A thick (~6 m), crossbedded sandstone marks the onset of Moenkopi Group deposition.

Overall, the Moenkopi Group is 27–30 m thick. Crossbedded sandstones predominate in the Moenkopi Group strata, with lesser lithologies, including cherty sandstones and mudstones. The Santa Rosa Formation unconformably overlies the Moenkopi Group and all three of its members (ascending order), Tecolotito, Los Esteros, and Tres Lagunas, are present. The Tecolotito Member (12 m thick) consists of crossbedded sandstones, some with chert, and sandy mudstone. The Los Esteros Member (54 m thick) has a lower third that is mudstone-dominated, a medial third that has crossbedded sandstones and sandy mudstones, and an upper third that is also mudstone-dominated. Crossbedded sandstones are the dominant lithology of the Tres Lagunas Member (14 m thick). The mudstone-dominated Garita Creek Formation overlies the Tres Lagunas Member. This unit is at least 94 m thick, though regional topography made it impossible to find a single section of the entire unit. The Trujillo Formation (26 m thick) is sandstone dominated with some mudstones. The Petrified Forest Formation (196 m thick) is almost entirely composed of mudstone, the exception being the cherty, crossbedded sandstone Correo bed that occurs in the upper third of the formation. The Rock Point Formation (56 m thick) is present as a series of sandy mudstones with occasional sandstone beds. The Lamy collecting area yields the type assemblage of the Lamyan sub-land vertebrate faunachron, including the famous Late Triassic Lamy amphibian quarry that has produced dozens of individuals of the metoposaurid amphibian *Buettneria perfecta*.

PRELIMINARY ANALYSIS OF GROWTH AND AGE STRUCTURE OF *BUETTNERIA* (AMPHIBIA: METOPOSAURIDAE) ASSEMBLAGES FROM THE UPPER TRIASSIC OF WEST TEXAS AND NEW MEXICO, *L. F. Rinehart*, larry.rinehart@state.nm.us, *S. G. Lucas*, New Mexico Museum of Natural History and Science, 1801 Mountain Road Northwest, Albuquerque, New Mexico 87104, *A. B. Heckert*, Department of Geology, ASU Box 32067, Appalachian State University, Boone, North Carolina 28608; and *A. P. Hunt*, New Mexico Museum of Natural History and Science, 1801 Mountain Road NW, Albuquerque, New Mexico 87104

Two mass death assemblages of the Upper Triassic temnospondyl amphibian *Buettneria perfecta* Case, the “Lamy bonebed” from the Garita Creek Formation in central New Mexico and “Rotten Hill” from the Tecovas Formation of west Texas, yield tens to hundreds of individuals. We used a statistical approach to resolve size classes (= age groups) in clavicles and interclavicles from which we generated a growth curve and age distribution for *Buettneria*. Comparison of these data to extant salamander outgroups (e.g., *Andrias*, *Cryptobranchus*, *Chioglossa*, others) and other amphibians showed that growth was indeterminate and that only sexually mature (marked by size, slow linear growth, and age distribution shape) adults were present in the fossil assemblages. They lived, on average, 10 or 11 yrs past sexual maturity. Linear size (measured by skull and femur length) increased by a factor of ~1.9 between sexual maturity and death, similar to the outgroups. Juvenile *Buettneria* are recognizable at very small sizes elsewhere in the Chinle Group, but are not present in these assemblages and are very rare in the fossil record even though population dynamics dictates that they must greatly outnumber adults. Where were the juveniles?

Analysis of the Rotten Hill population showed that the diameter of *Buettneria's* limb bones grew in strong negative allometry; e.g., the allometric constant for femur length versus midshaft diameter = 0.78, where a constant of 1.5 is required to maintain constant stress on the limb bones throughout growth. Thus, weight-bearing capacity of the limbs decreased drastically throughout adulthood.

We propose that in addition to taphonomic influences against preservation of the juveniles, their absence may be due to an ecological separation from the adults. Separation of adults and juveniles is known in some extant amphibians and probably serves to reduce competition for food and conspecific predation of the juveniles. The increasingly weaker limb bones of the adults could have enforced such an ecological separation by making adults water-bound while the juveniles could have been more terrestrial or littoral. If so, this may explain the extreme preservational preference for adults; burial and fossilization being much more likely in their aquatic habitat.

A ^{40}AR/^{39}AR SINGLE-CRYSTAL SANIDINE AGE FOR AN ALTERED VOLCANIC ASH BED FROM THE PALEOCENE NACIMIENTO FORMATION IN THE SOUTHERN SAN JUAN BASIN SHEDS NEW LIGHT ON THIS FORMATION'S STRATIGRAPHIC AND BIOCHRONOLOGIC ESSENCE, *J. E. Fassett*, jimgeology@qwest.net, U.S. Geological Survey, Emeritus, 552 Los Nidos Drive, Santa Fe, New Mexico 87501; *M. T. Heizler*, and *W. C. McIntosh*, New Mexico Bureau of Geology and Mineral Resources, New Mexico Institute of Mining and Technology, Socorro, New Mexico 87801

The first ^{40}Ar/^{39}Ar single-crystal age for Paleocene strata in the San Juan Basin was obtained from sanidine crystals recovered from an altered volcanic ash bed in the Nacimiento Formation at Mesa de Cuba in the southeast part of the basin. This age is 64.49 ± 0.38 Ma (2 sigma) and is based on single-crystal sanidine results relative to Fish Canyon Sanidine at 28.28 Ma and a total 40K decay constant of 5.53E-10/a. Due to significant contamination by older K-feldspar crystals, this date is considered a maximum depositional age. The dated ash bed is 119 m above the Cretaceous–Tertiary interface and is 76 m above the base of the Nacimiento/top of the Ojo Alamo Sandstone. This age places the dated ash bed near the top of magnetochron C29n. The lower part of chron C29n was identified within the underlying Ojo Alamo Sandstone at Mesa Portales, about 12 km south of Mesa de Cuba; the base of this chron is 98 m below the dated ash bed. This age determination allowed a calculation of the rate of sedimentation for underlying Paleocene strata of 173 m/m.y (not corrected for compaction). Extrapolating this rate of deposition to overlying Nacimiento Formation strata to the base of the Eocene San Jose Formation places this contact at 63.40 Ma. Because the Paleocene–Eocene contact is 55.8 Ma, an enormous unconformity of about 7.6 m.y. must be present at the Paleocene–Eocene contact at Mesa de Cuba (assuming there are no significant, intervening unconformities present in Nacimiento strata overlying the dated ash bed). Puercan and (or) Torrejonian mammal fossils have been found at numerous localities in the southern San Juan Basin, including at Mesa de Cuba. Because this dated ash bed is slightly above the boundary between these two land-mammal zones, it is estimated that the Puercan–Torrejonian boundary has an age of about 64.6 Ma thus making the duration of the Puercan land-mammal age 0.9 m.y. in the San Juan Basin.

EXHUMATION HISTORY OF THE SAN JUAN BASIN, *S. Braschayko*, sbrasch@nmt.edu, Department of Earth and Environmental Science, New Mexico Institute of Mining and Technology, Socorro, New Mexico 87801; *S. A. Kelley*, New Mexico Bureau of Geology and Mineral Resources, New Mexico Institute of Mining and Technology, Socorro, New Mexico 87801; and *D. Stockli*, The University of Kansas, Lawrence, Kansas 66045

Low temperature thermochronology and sonic log data are combined to assess the post-Oligocene unroofing history of the San Juan Basin. Preliminary apatite (U-Th)/He data indicate that rocks as shallow as 385 m were at temperatures above 70ºC until about 4–5 Ma and have since cooled. Apatite fission track (AFT) data suggest higher temperatures to the north with cooling below 110ºC occurring in the late Miocene. The San Juan Basin cooled from T>110ºC due to erosional exhumation from <15 Ma. AFT ages in the San Juan Basin decrease toward the north.

Interval transit time, which is the reciprocal of sonic velocity, can be measured from sonic geophysical well logs and used to estimate relative amounts of exhumation across an area. This technique is very useful due to the ubiquity of sonic logs and the relative efficiency with which the data can be processed. This method can be used as a cross-check of erosion estimates determined from low temperature thermochronology data and can be used to evaluate exhumation versus heat flow variations across a basin. Interval transit time decreases exponentially with increasing burial depth according to a compaction curve calibrated for each rock unit examined. Because rock compaction is an irreversible process, rock units that are at a depth shallower than their maximum burial depth will have a lower-than-expected interval travel time relative to the calibrated compaction curve. The calibrated compaction curve for the Mancos Shale in the San Juan Basin was determined from over 100 well logs. The average interval transit time for Mancos Shale at depths shallower than 915 m ranges from about 75 to 110 µs/ft and shows a pronounced exponential decrease in interval travel time with depth. The maximum amount of relative exhumation recorded by the shale sonic log data is 1.2 km in the San Juan River valley; however, the typical amount of relative exhumation in the San Juan Basin is less than 1 km.

LINKS BETWEEN THIRD-ORDER (M.Y.-SCALE) SEA-LEVEL AND CLIMATE CHANGE IN THE UPPER ORDOVICIAN MONTOYA GROUP, SOUTHERN NEW MEXICO, *M. A. Tyra*, *M. Elrick*, and *V. Atudorei*, Department of Earth and Planetary Sciences, University of New Mexico, Albuquerque, New Mexico 87131

The Upper Ordovician Montoya Group (southern New Mexico, west Texas) was deposited on a southward-dipping ramp and contains up to six 3rd-order stratigraphic sequences. These sequences have been correlated by Pope (2004) and Harris et al. (2004) to similar sequences across North America and Estonia. These correlations suggest eustatic sea-level change as the driver; their root cause (tectonic or climatic), however, remains an open question. We are testing the hypothesis that the rock magnetic signal covaries with 3rd-order sea-level change in the Late Ordovician.

We measured the lower two sequences (30–70 m) of the Montoya Group in the Cookes Range, near Deming, New Mexico, which are composed of deep-to-shallow ramp carbonates (Pope 2004). We are comparing sea-level-driven facies changes to rock magnetic values (magnetic susceptibility and anhysteretic remnant magnetization) to evaluate the links between m.y.-scale changes in sea level and climate. Rock magnetics can be used as a climate proxy for investigating changes in wind intensity/aridity, and/or fluvial sediment influx. Preliminary results show that rock magnetics (2–5 m sampling resolution) in the lower sequence and interpreted sea level covary. Here decreasing magnetic values coincide with transgression (and vice versa) suggesting either wind-intensity/aridity decreased during sea-level rise and/or the influx of fluvially derived material to the deep ramp decreased. Rock magnetics from the younger sequence show a more complex relationship with sea-level change, which we are presently investigating. To better understand Late Ordovician climate change, we also are extracting conodont apatite from the sequences to examine their oxygen isotopic composition (a climatic proxy for both temperature and ice volume). These isotopic values will further constrain the links between m.y.-scale sea-level and climate change.

DIGITAL SOIL MAPPING—EVALUATING THE USE OF REMOTELY SENSED DATA,

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The creation of accurate small scale soil maps is often very difficult due to time and cost constraints. The traditional methods of soil mapping include using several sets of proxy data to identify boundaries. Aerial photographs are often the most useful due to the amount of detail they often show, from clusters of trees to outcrops of rock. With these data, a soil scientist can infer more detail about soil changes based on the land cover. It is possible for an experienced soil scientist to be able to associate certain landforms with sets of internal soil properties. Using these aids, among others, it is possible to get a preliminary idea of where boundaries will occur. This allows the researcher to have a plan, before going in the field, of where he needs to spend the most time. Most time in the field will be spent crossing back and forth across these boundaries to confirm or change them as necessary.

Digital soil mapping is the computer-based operationalization of ideas for predicting soil distribution and has become more feasible with the advance of computational technology. Remote sensing techniques can provide data that are spatially contiguous and spectrally contiguous, and it has been used successfully in the past to carry out land use and land cover surveys. It provides a quicker and more efficient method of mapping soils.

Using data from the Landsat 7 processed through the SEBAL model, visual correlations are seen between parameters such as albedo, surface temperature, normalized difference vegetation index, evapotranspiration and soil moisture, and soil unit. Visual analysis has been completed at two very different field sites, the Sevilleta National Wildlife Refuge and the Hilton Ranch. In both areas unsupervised classifications have been performed to analyze any correlations with soil unit. More detailed field data have been collected at the Sevilleta, further quantifying the visual correlations.

SESSION 3—RIO GRANDE RIFT, ALBUQUERQUE AND SOUTHERN BASINS

STRUCTURAL AND STRATIGRAPHIC IMPLICATIONS OF OIL AND GAS DRILLING AND SEISMIC EXPLORATION DATA IN THE ALBUQUERQUE BASIN OF THE RIO GRANDE RIFT, CENTRAL NEW MEXICO,

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One north-south seismic line parallel to the long axis of the Albuquerque Basin and east-west lines across all or parts of the basin (in conjunction with the well control from the deeper exploration tests that have penetrated the Cretaceous rocks) shed significant light on the structural style and the timing history of the opening of the Rio Grande rift in this part of New Mexico.

This exploration data also show dramatic and possibly unexpected structural partitions and sub-basins as well as hidden faults and horst and graben structural geometries in the larger rift structure. Of structural importance is the recognition of Laramide thrusts and their location and effect on pre-rift structures in the basin.

Insight into the timing and abruptness of syn-rift basin fill is dramatically seen on the seismic. Also strikingly illustrated is the changing tectonic style of bounding faults on the western side of the rift margin from south to north.

Of interest is the apparent effect of the possible continuation of the Tijeras shear into and across the basin between the Belen sub-basin to the south and the Calabacillas sub-basin to the north. This zone of disturbance (Tijeras accommodation zone) may help put constraints on the amount of lateral movement that has taken place in the rift—through time in this part of the rift. An additional accommodation zone may be present in the basin as a possible southwest extension of the Placitas fault.

USGS Bulletin 2184, published in 2001, supports the theory that the Albuquerque Basin may contain a large basin-centered gas deposit in the rift. Recent activities by Tecton Energy, LLC, working with Black Oil suggest a multi-TCF gas and hundred-million-barrel oil accumulations may exist within the deeper downthrown areas of the rift.

Sub-basins in the Albuquerque Basin have abundant source rock, a favorable history of maturity, and probable extensive reservoir systems. Structural complexities, including Laramide thrusting, as well as stratigraphic variation will account for a portion of any trapped oil and gas. Post-Oligocene subsidence has allowed coeval maturation of the Cretaceous source and a dramatic reduction in permeability of Tertiary and Cretaceous sandstones. This may have effectively created a barrier for rapidly expelling hydrocarbons in separate sub-basins.

STRUCTURAL AND STRATIGRAPHIC CONTROLS OF DEEP BRACKISH WATER EXPLORATION, RIO PUERCO BASIN, NEW MEXICO,

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Two exploratory wells were drilled in the Rio Puerco valley west of Rio Rancho during the summer of 2007 by Sandoval County and a residential developer. Exp-6 spudded in thin alluvial cover just east of the surface trace of the Moquino fault and ended 3,850 ft below ground surface (bgs). It was screened between 3,598 and 3,809 ft bgs in the Aqua Zarca Member of the Chinle Formation and in the San Andres and Glorieta Formations, respectively. Exp-5 (total depth of 6,450 ft bgs, reaching Precambrian basement rock at 6,350 ft) was screened in six intervals between 3,360 and 4,820 ft bgs from the Aqua Zarca to the Yeso Formation. Exp-6 yielded approximately 600 gallons per minute (gpm) of water. Exp-5 initially produced approximately 20 gpm of artesian flow. After a commercial fracturing procedure, Exp-5 flowed at a sustained rate of approximately 150 gpm. Ground water from the wells contains approximately 12,000 mg/l TDS, 3,100 mg/l chloride, and 4,400 mg/l sulfate.

Drilling Exp-6 through the Moquino fault made for difficult stratigraphic correlation until reaching the Todilto gypsum beds at approximately 1,685 ft bgs. After drilling Exp-5, units correlated between the two holes up to 1,415 ft bgs in Exp-6. Using that depth for the intersection of the fault with the well and an estimated surface trace of the fault 230 ft west of the well indicates the fault dips approximately 81° east.

The Moquino fault juxtaposes the marine shales of the Mancos Shale and the deltaic, coal-bearing sandstones of the Menefee Formation. Vertical displacement may be as much as 2,285–2,785 ft based on published unit thicknesses. The displacement on the Moquino fault is an example of how geologic structure can impact the economics of resource development. On the west side of the fault, the top of the producing interval is 3,598 ft bgs. On the east side of the fault, the top of the producing zone could be as deep as 6,383 ft bgs, nearly doubling the cost to drill for that zone.

AQUIFER CHARACTERISTICS OF THE SANTA FE GROUP IN NORTHERN RIO RANCHO,

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Subsurface data (lithologic and geophysical logs) collected from three deep municipal supply wells and one exploratory well are used in conjunction with data from long-term (7-day) pumping tests, remote sensing data (aeromagnetic surveys), geologic mapping, and geochemistry data to determine variations in subsurface stratigraphy, chemistry, and aquifer characteristics in a portion of the Albuquerque Basin. City of Rio Rancho wells 10A, 22, and 23 are completed to depths of between 2,000 and 3,000 ft in the Santa Fe Group aquifer. Lithologic and geophysical logs from the wells indicate the presence of aerially extensive subsurface units that can be correlated over distances of at least several miles in deep wells. A 3,000 ft deep exploratory boring (completed as a 2,880 ft deep cased test well) at the well 23 site was zone sampled for water quality. Significant variations in water quality are recognized in samples collected below 2,000 ft vs. samples collected at 2,000 ft or less in the test well. Spinner logs conducted in the test well indicate significant upward vertical ground water gradient in the aquifer. Clays encountered from 2,100 ft to 2,460 ft in well 23 act as significant confining beds. The upper portion of these clays are correlative to clays encountered in the bottom of wells 10A and 22, which are also interpreted as confining beds for the deeper Santa Fe Group sediments. Water quality degrades rapidly (TDS > 4,500 mg/L) below the confining beds in the well 23 test well, and composite borehole chemistry in well 22 and well 10A indicate a similar increase in TDS below the clay beds. Although pumping test and chemistry data indicate that faults identified in the area from surface mapping and/or aeromagnetic surveys act as barriers to ground water flow, stratigraphy and the presence of a regional confining bed are more significant controls on water quality in the deep aquifer system.

PROGRESS REPORT ON TRACKING RIO GRANDE TERRACES ACROSS THE UPLIFT OF THE SOCORRO MAGMA BODY, *D. W. Love*, dave@gis.nmt.edu, *D. J. McCraw, R. M. Chamberlin, S. D. Connell, S. M. Cather*, New Mexico Bureau of Geology and Mineral Resources, New Mexico Institute of Mining and Technology, Socorro, New Mexico 87801; and *L. Majkowski-Taylor*, Department of Earth and Environmental Science, New Mexico Institute of Mining and Technology, Socorro, New Mexico 87801

Historically, the ground surface above the sill-like Socorro Magma Body has been rising on the order of 2–4 mm per yr, whereas subsidence has occurred beyond its margins. For the past 25 yrs, oft-cited articles have reported that terraces along the Rio Grande are deformed by uplift, but the original articles did not include detailed descriptions of the terrace deposits. Ongoing geologic mapping of 7.5-min quadrangles along the Rio Grande from Veguita to San Antonio across the southern Albuquerque Basin, the Socorro Magma Body, and the relatively narrow Socorro Basin shows three early to middle Pleistocene terrace deposits, local late Pleistocene terrace deposits, and top(s) of early Pleistocene fluvial basin fill. Lessons learned while tracing these discontinuous deposits southward include: 1) Original maximum fluvial aggradational elevations may be preserved only locally, especially compared to the southern Albuquerque Basin and the northern Palomas–Jornada Basin; 2) Commonly some lesser elevation of fluvial deposits is preserved by interfingering with less erodible coarse-grained valley-border fans; 3) Coarse sediments from the Rio Salado have affected the course of the Rio Grande and partially buried Rio Grande terrace deposits over several square kilometers; 4) If the historic Socorro Magma Body uplift rate were constant, a 100,000-yr-old terrace tread should be about 200–400 m higher, and older treads should have undergone even more uplift; 5) Short-term elastic uplift is generally viewed as domelike, but longer-term uplift could cause sufficient stretching to trigger longitudinal collapse of keystone grabens, so terrace heights might not be affected or terraces might subside in places; and 6) Multiple north-trending rift-related faults in the Socorro Basin south of San Acacia significantly affect the elevations of Bandelier ashes preserved in axial fluvial deposits (by as much as 20 m), making estimates of maximum aggradation or stream gradients uncertain.

Investigations to date show no major uplift of Rio Grande terrace treads from the southern Albuquerque Basin across the northern part of Socorro Magma Body uplift, implying either that 1) current uplift may be too recent to be recorded in the terrace succession, or 2) current uplift is at a maximum rate, or 3) this reach is affected by both subsidence and uplift at the northeast edge of the Socorro Magma Body, or 4) long-term uplift is matched by episodic subsidence of the surface. Within the Socorro Basin above the Socorro Magma Body, however, ample evidence of fault-bounded uplift, subsidence, and extensive valley-border erosion contrasts with the reaches to the north and south within the rift. These observations affect not only interpretations of the duration of uplift, but also hypotheses of a possible smaller shallow magma body and geologically reasonable rates of magma injection into the Socorro Magma Body.

GEOHYDROLOGIC INVESTIGATION OF THE SOUTHERN CHUPADERA MOUNTAINS AREA—AVAILABILITY AND SUSTAINABILITY OF WATER SUPPLIES FOR DOMESTIC USE, *M. J. Darr*, mjdarr@nmia.com, MJDarrconsult, Inc., 6729 Green Valley Place NW, Albuquerque, New Mexico 87107

The geology and hydrology of the southern Chupadera Mountains and the basin immediately west were investigated as part of a water availability assessment for subdivision water supply. The study area includes the bajada on the southeast margin of the Magdalena Mountains and the south side of the Chupaderas above the Rio Grande valley floor near San Marcial in Socorro County, New Mexico.

More than 21,000 acres (33 sections) were evaluated for over 800 twenty-plus-acre homesites in three phases. After three initial exploratory boreholes were advanced, eight wells were drilled and tested in alluvium and Santa Fe Group materials in the bajada, and seven wells in the tuffs and volcanoclastic materials of the southern Chupaderas. A number of existing wells were also pump-tested and sampled. Test data were integrated with geologic maps, satellite imagery, and literature research to develop a comprehensive picture of the area's hydrogeology. Areas unsuitable for subdividing into lots based on hydrologic factors were excluded from the final layout plans and totaled several thousand acres.

Results show a surprising subsurface complexity beneath the veneer of alluvium covering the bajada. The basement configuration consists of en echelon fault blocks, overlain by Santa Fe Group sedimentary materials interbedded with tuffs and rhyolites. Transmissivity of the basin-fill materials averages about 650 ft^2/day (square feet per day) for domestic wells that tap the aquifer. Wells completed in interbedded volcanics have similar transmissivity values, averaging 570 ft^2/day. Expected yields are 5–10 gpm (gallons per minute), and water quality is generally excellent.

The hydrology of the Chupadera Mountains, by contrast, is dominated by the distribution of fractured volcanic materials (the La Jencia and Lemitar Tuffs) lying atop relatively impermeable volcaniclastic materials (clay-rich Spears Group). Transmissivity in the main aquifer zone averages about 17,250 ft^2/day, indicating much higher production (greater than 50 gpm). Outside of the main aquifer zone, transmissivity drops to less than 10 ft^2/day and well yields are marginal. Water quality is excellent in the main aquifer zone, with no dissolved arsenic problems encountered.

Aquifer test results were used in site-specific Theis calculations and/or MODFLOW ground water flow models to predict the future drawdown effects of withdrawals for water supply. The results indicate that drawdowns are minimal due to low lot density and good aquifer transmissivity. Calculations show that projected water use can be sustained by aquifer storage for 200–300 yrs at the project locations. The total projected water use in the area is close to 500 AFY (acre-feet per year) or about 20% of published regional recharge estimates to the Rio Grande valley in this area, suggesting that the local water supply could be sustained indefinitely.

CONDUCTIVE HEAT FLUX OVER SELECTED GEOTHERMAL SYSTEMS IN THE RIO GRANDE RIFT AND ADJACENT AREAS SUGGESTS A PROCESS OF SHALLOW HYDROTHERMAL SYSTEM SIZE SCALING, *J. C. Witcher*, jimwitcher@zianet.com, Witcher and Associates, P.O. Box 3142, Las Cruces, New Mexico 88003

Geothermal reservoirs in a rift setting can be static or dynamic. Static geothermal systems represent deep-seated and confined reservoirs with temperatures that correspond to the temperature gradients associated with background upper crust heat flow. On the other hand, dynamic reservoirs or systems have active upflow and associated outflow plumes that convectively and/or advectively transfer deep-seated heat closer to the surface. The upflows and outflow plumes represent the flow paths and shallow storage or reservoirs for geothermal fluids. Because of the arid nature of Rio Grande rift region, many, if not most, geothermal systems are "blind" to surface hydrology and lack hot springs. This presents an opportunity to estimate total system thermal output by summation of conductive heat flow above the water table across the area of the upflow and outflow plume for a particular system. Six to eight geothermal systems in the southern Rio Grande rift region are of sufficient exploration maturity to assess natural conductive thermal output, estimate reservoir volume, and assess probable base or highest reservoir temperatures. There is an apparent inverse size scaling of thermal output in relation to base reservoir temperature. The largest thermal outputs correspond to very large reservoir volumes and low temperature (<100° C). On the other hand, systems with moderate-to-high temperature (>100° C) are associated with much smaller total heat flux and apparent reservoir volumes. Hydrogeology appears to play an important role. The largest systems may have more broadly distributed zones of upflow with large outflow plumes at shallow and intermediate depths (<1 km) in Paleozoic carbonate reservoirs. The smaller systems are intensely focused by a variety of bedrock structures that feed shallow outflow plumes of less extent in mostly Cenozoic basin-fill deposits.

THE RIO GRANDE RIFT IN MEXICAN PERSPECTIVE, *W. E. Elston*, welston@unm.edu, Department of Earth and Planetary Sciences, University of New Mexico, Albuquerque, New Mexico 87131

Seen from the south, the Rio Grande rift appears as an arm of the Mexican Basin and Range province. In central Mexico, a Laramide fold-and-thrust belt was inundated by mid-Tertiary volcanism, culminating in the great ignimbrite flareup. As associated heat flow subsided, and ductile extension gave way to brittle extension, basin and range fault blocks developed in the eastern part of the province. Its western part, the Sierra Madre Occidental, remained a relatively undisturbed volcanic plateau. In the southwest corner of New Mexico, the central Mexican province split: As the main fold-and-thrust belt bent northwest and continued into Arizona, it cut across the Sierra Madre Occidental, leaving the Mogollon–Datil volcanic field as a northern outlier. A lesser branch headed north, as the Rio Grande rift system.

North of Hatch, the Rio Grande valley marks the major fracture zone separating the extending western third of the continent from its more stable interior. The degree to which a distinct rift developed depended on the absence of crust "softened" by residual heat from mid-Tertiary volcanism. In the absence of volcanism, a distinct topographic and structural rift border developed on the east side of the Palomas Basin, along the Caballo–Fra Cristobal front. The "soft" west sides splintered into grabens around the Mogollon Plateau pluton, core of the Mogollon–Datil field. Along the San Augustin Plains, this graben system merged with the Socorro accommodation zone, which translated the Rio Grande rift 50 km northeast and remained a site of minor siliceous volcanism into the Neogene. The east border of the Albuquerque–Belen Basin remained rifted along the Manzano–Sandia front. On the "soft" west side, intra-rift basaltic volcanism was active into the Pleistocene. The Jemez volcano-tectonic lineament again translated the rift 50 km northeast; its volcanism climaxed in the Pleistocene Valles caldera. The Española Basin has distinct rift borders on both east (Sangre de Cristo) and west (Chusas) sides. Thick intra-rift basalts resemble a failed ocean ridge. A monocline on the "soft" west side of the San Luis Basin borders the mid-Tertiary San Juan volcanic field; the Sangre de Cristo block continues on the east side. In the Arkansas Valley the rift narrows into a fault zone buttressed on both sides by Rocky Mountain fault blocks.

SESSION 4—HYDROGEOLOGY AND CLIMATE

SULFUR ISOTOPE SIGNATURES IN GYPSIFEROUS SEDIMENTS OF THE TULAROSA AND ESTANCIA BASINS AS INDICATORS OF SULFATE SOURCES AND THE LOCAL HOLOCENE HYDROLOGIC CYCLE, *A. Szynkiewicz*, aszynkie@indiana.edu, *L. M. Pratt*, Department of Geological Sciences, Indiana University, 1001 E 10th Street, Bloomington, Indiana 47405; *M. Glamoclija*, Geophysical Laboratory, Carnegie Institution of Washington, 5251 Broad Branch Road NW, Washington, DC 20015; *C. H. Moore, E. Singer*, Department of Geological Sciences, Indiana University, 1001 E 10th Street, Bloomington, Indiana 47405; and *D. Bustos*, White Sands National Monument, P.O. Box 1086, Holloman Air Force Base, New Mexico 88330

Pleistocene/Holocene gypsiferous lake sediments of the Tularosa Basin (White Sands area) and Estancia Basin were studied, using sulfur isotope methods, to try and identify primary sulfate sources and determine the hydrologic cycle during the Holocene tectonic evolution of these basins.

Four sections of lake sediments taken from different sites in the White Sands area show wide variation in the $\delta^{34}S$ values of sulfate minerals (from 2.2–13.8 ‰ vs. VCDT) suggesting different sulfate sources for and different sedimentary environments in the southern and northern parts of the study area. In the southern part, mixing process between sulfate-rich fluids originating from the dissolution of the middle (10.9–12.3 ‰) and Lower (12.5–14.4 ‰) Permian strata is indicated by a steady increase of $\delta^{34}S$ values (11.3–13.8 ‰) and linked to discharge of deeper-seated ground water through fault-related fractures. This process was probably controlled by climate change and/or episodes of increased tectonic activity. Areas of ground water discharge related to dissolution of Lower Permian strata were recognized based on alignments of gypsum-rich domes, visible on aerial photographs taken in October of 2007, with regional faults. The $\delta^{34}S$ values of sediments from the northern part of the basin are dominated by sulfate (10.6 to 12.4 ‰) originating from the dissolution of the middle Permian strata. However, three episodes of negative excursion of $\delta^{34}S$ values (up to 2.2 ‰) suggest episodes of water influx with lower $\delta^{34}S$ values that may be linked to the leaching of sulfate during near-surface weathering of sulfides.

Values of $\delta^{34}S$ significantly higher (median 17.4 ‰) than those for sulfates derived from fluids that interacted with Lower Permian strata are found in sulfate-rich lake sediments from the Estancia Basin. This suggests the involvement of bacterial sulfate reduction processes. Higher organic carbon content in sediments from the Estancia Basin (median 0.46 %) compared to the White Sands area (median 0.07 %) is consistent with higher rates of bacterial sulfate reduction and the consequent overprinting of sulfur isotope signatures that would elucidate Holocene fluid flow paths.

MALPAIS SPRING AND MALPAIS SALT MARSH, NORTHERN TULAROSA BASIN, NEW MEXICO, *R. G. Myers*, U.S. Army, IMWE-WSM-PW-E-ES, White Sands Missile Range, New Mexico 88002; *B. D. Allen*, and *D. W. Love*, New Mexico Bureau of Geology and Mineral Resources, New Mexico Institute of Mining and Technology Socorro, New Mexico 87801

The Malpais Spring and Malpais Salt Marsh are located at the end of the distal section or southwestern edge of the Carrizozo (or Malpais) olivine-basalt lava flow in the northern Tularosa Basin within White Sands Missile Range, New Mexico. The Carrizozo lava flow was originally believed to be about 1,200 yrs old based on visual observations. Work by Saylards (1991) and Dunbar (1999) determined that the flow was actually about 5,000 yrs old. The Malpais Spring and Malpais Salt Marsh are one of two endemic localities of the White Sands pupfish (*Cyprinodon tularosa*).

Most of the ground water discharge from the Malpais Spring area occurs as several springs and seeps. The aquifer for Malpais Spring consists of the regional Quaternary/Tertiary alluvial bolson fill and the buried stream-channel sediments underneath the basalt flow. Enough flow occurs in one area to form a stream channel that flows to a wetland or salt marsh. The delineated wetlands, which encompassed approximately 1,188 acres in 1997, have a salt-marsh ecosystem. The dominant species of marsh vegetation are salt grass (*Distichlis spicata*), iodine bush (*Allenrolfea occidentalis*), and spike rush (*Eleocharis palustris*). Some areas of the wetlands are seasonally inundated by water.

The flow of Malpais Spring was estimated to be 2,000 gallons per minute (gpm) in 1911 and 1,500 gpm in 1955. Instantaneous flow rates measured near the top of the main stream channel between 1984 and 2007 ranged from 290 to 1,200 gpm. These measurements do not include the flow from some seeps and springs that discharge near this stream channel and the upper marsh area. A stream gage was installed on this stream channel by the U.S. Geological Survey and began operation on 25 July 2003. At least two peak flows of about 1,930 gpm were recorded during January 2004 and August 2006.

Water quality at the points of discharge in the Malpais Spring area has remained somewhat constant over recent times. The total dissolved solids (TDS) concentrations (ROE @ 180°C) for 14 samples collected from 1962 to 2007 varied from 4,760 to 5,200 milligrams per liter. The TDS concentrations at the lower end of the salt marsh can be about twice that of the point of discharge due to evapotranspiration from vegetation and evaporation from the water surface.

THE BIOGENENICITY OF DESERT VARNISH AND CAVE FERROMANGANESE DEPOSITS, *A. E. Dichosa*, Department of Biology, University of New Mexico, Albuquerque, New Mexico 87131; *M. N. Spilde*, Institute of Meteoritics, University of New Mexico, Albuquerque, New Mexico 87131; and *D. E. Northup*, Department of Biology, University of New Mexico, Albuquerque, New Mexico 87131

The beautiful colors that paint the desert rocks and the karst cave walls are primarily due to the oxidation of iron (Fe^{2+}) and manganese (Mn^{2+}). On the terrestrial arid landscape, where weathering and sunlight persist, these oxide layers are called desert varnish. In the subsurface cave environment, where weathering and sunlight are limited or nonexistent, they are called ferromanganese deposits (FMD). Though this oxidation process can be attributed to abiotic factors, recent evidence suggests that microbial influences contribute to these formations for purposes of protection and energy production. However, the exact mechanisms by which they perform this simple activity are not completely understood. This research hypothesizes that microbes mediate Fe^{2+} and Mn^{2+} oxidation, thereby contributing to and influencing the delicate ecosystems of both extreme environments. To test this hypothesis, we pose the following questions: 1) Who are the microbes that comprise the desert varnish and cave FMD?; 2) Are there common and/or novel microbial species present?; 3) Are there any Fe^{2+} and Mn^{2+}oxidizers?; and 4) How are the necessary substrates acquired from their environments?

This investigation begins with samples aseptically collected from Socorro, New Mexico, and from Spider Cave in Carlsbad, New Mexico. DNA was extracted for the amplification of representative 16S rRNA genes (~569 bp) via the polymerase chain reaction. Denaturing gradient gel electrophoresis (DGGE) assays were run to identify the relative number of microbial species from each community. Banding patterns suggest common microbial members and that dominant species are also present. Selected bands were picked and reamplifed for subsequent nucleic acid sequencing and phylogenetic analyses. NCBI BlastN shows the presence of bacteria whose closest relatives are the *Alpha*-, *Beta*-, and *Gammaproteobacteria*, *Cyanobacteria*, and *Bacteroidetes*. Novel species are suggested, including one whose closest relative is found in the marine environment. Scanning electron microscopy (SEM) reveals the presence of bacteria of various sizes, some possessing unique physiological features that indicate direct interactions with their environment. Classic culturing techniques show the presence of oxides, indicating a similar biogenic process found in the natural environment.

GEOCHEMISTRY AND POTENTIAL SOURCES OF THE JANUARY 7, 2008, SOUTHWESTERN NEW MEXICO "MILKY RAIN", *J. Gilbert*, jhgilbert@utep.edu, Environmental Science Program, University of Texas at El

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On the afternoon of January 7, 2008, an approximately 1,300 km^2 region of Grant County, New Mexico, stretching northeast from White Signal, New Mexico, to Gila Cliff Dwellings, was subject to rainfall of milky-white color. Concerned residents, who collected samples from cisterns, rain gages, and roof runoff, contacted area universities and state agencies to arrange for chemical analyses. Initial speculation targeted everything from mine tailings to Pacific Rim volcanic ash before wind back trajectories and MODIS satellite images indicated a possible regional source: Willcox playa sediments. Analysis of major ions indicated elevated levels of calcium, sodium, sulfate, and chloride, as would be expected in playa-type deposits. Ratification came from a National Atmospheric Deposition Program site at the Gila Cliff Dwellings, which determined the calcium content of the rain to be within the top 1.0% of all data gathered by the network in a typical 5 yr period. On February 5, 2008, the New Mexico Environment Department concluded that the event samples had similar chemistry to surface water samples obtained from the Lordsburg playas in the early 1990s and reassured the public regarding its possible toxicity. Further research will include trace element analysis of dissolved constituents in the rain water, analysis of the suspended (non-dissolved) materials and recently acquired dust samples. We present an overview of this event, the meteorological characteristics of the "milky rain" storm, and the geochemistry of the materials.

AN INDEX OF THE ONSET OF THE NORTH AMERICAN MONSOON SEASON IN CENTRAL NEW MEXICO, *P. Higgins*, phiggins@unm.edu, *D. Gutzler*, Department of Earth and Planetary Sciences, University of New Mexico, Albuquerque, New Mexico 87131; and *D. Kann*, NOAA National Weather Service, Albuquerque, New Mexico 87106

We develop an objective index to indicate the start of the monsoon season in central New Mexico using data from several measuring stations around Albuquerque. The weather variables being considered include dew point, daily precipitation, relative humidity, and wind. With these data we are attempting to define and quantify noticeable changes that mark the onset of a prolonged summer rainy season. We find that there appears to be dew point threshold (analogous to monsoon onset indices developed for sites in Arizona) that may indicate the start of the monsoon, consistent with the onset of persistent precipitation that nearly matches the accepted historic start date of July 7th.

At this time we are refining the monsoon onset criterion based on precipitation and dew point, to take into account "false starts" that may be associated with transient mid-latitude weather systems but are not associated with a large-scale monsoon circulation. We will develop a time series of onset dates to examine the relationships between monsoon onset, total seasonal precipitation, and possible antecedent predictors of the monsoon, and to consider whether the onset date has been changing during the past several decades.

POSTER SESSION 1—PALEONTOLOGY

TURONIAN AMMONITES FROM THE UPPER CRETACEOUS CARLILE AND SEMILLA SANDSTONE MEMBERS AND REFERENCE AREA OF THE JUANA LOPEZ MEMBER OF THE MANCOS SHALE, EASTERN SIDE OF THE SAN JUAN BASIN, LA VENTANA, SANDOVAL COUNTY, NEW MEXICO, *P. L. Sealey* and *S. G. Lucas*, New Mexico Museum of Natural History and Science, 1801 Mountain Road NW, Albuquerque, New Mexico 87104

At the reference section of the Juana Lopez Member of the Mancos Shale near La Ventana in central New Mexico, the unit is thick and well exposed. In 1966 Dane and others reported a reference section of 107 ft thick, the same thickness as the type section at Galisteo Dam. The Juana Lopez consists of three lithic intervals—lower calcarenites, middle shale, and upper calcarenites, and is underlain by the Carlile Member of the Mancos Shale. Only the upper part of the Carlile Member is exposed at La Ventana, and the Semilla Sandstone Member is very thin. The ammonite fauna from the Carlile and Semilla includes *Prionocyclus hyatti* (Stanton), *Coilopoceras springeri* Hyatt, *Romaniceras* (*Romaniceras*) *mexicanum* Jones and *Placenticeras cumminsi* Cragin. The ammonite fauna from the Juana Lopez includes *Scaphites whitfieldi* Cobban, *Prionocyclus novimexicanus* (Marcou), *Prionocyclus macombi* Meek, *Coilopoceras colleti* Hyatt and *Baculites* sp. Ammonite diversity in the upper calcarenite interval of the Juana Lopez is lower than at the type section. It includes primarily *P. novimexicanus*, secondarily *S. whitfieldi*, and rarely *Baculites* sp. The middle shale interval, as at the type section, has a low diversity ammonite fauna dominated by *P. macombi* with an occasional *C. colleti*. The *P. hyatti* Zone, present in the Carlile Member at La Ventana, also occurs in other places in New Mexico, especially in the Carlile Member at Galisteo Dam. The *P. macombi* and *P. novimexicanus* Zones are present in the Juana Lopez Member at La Ventana. The *P. macombi* Zone also occurs in many other places in New Mexico, including the basal part of the Juana Lopez Member in Colfax County, where the lectotype of *P. macombi* was collected. The zone of *P. novimexicanus* also occurs at various New Mexico locations, especially in the D-Cross Member of the Mancos Shale. The *P. hyatti* Zone is of middle Turonian age, the *P. macombi* Zone is of late-middle Turonian age, and the *P. novimexicanus* Zone is of late Turonian age.

LATE PLIOCENE (BLANCAN) VERTEBRATE FAUNAS FROM PEARSON MESA, HIDALGO COUNTY, NEW MEXICO, AND GREENLEE COUNTY, ARIZONA, *G. S. Morgan*, gary.morgan1@state.nm.us, *P. L. Sealey*, and *S. G. Lucas*, New Mexico Museum of Natural History and Science, 1801 Mountain Road NW, Albuquerque, New Mexico 87104

Exposures at Pearson Mesa in the Duncan Basin along the New Mexico–Arizona border have produced a diverse assemblage of late Pliocene (Blancan) vertebrates. The stratigraphic section at Pearson Mesa consists of more than 60 m of sandstones, mudstones, and sedimentary breccias of the Gila Group. Two distinct vertebrate faunas occur at Pearson Mesa: the early late Blancan Pearson Mesa Local Fauna (LF) is derived from the lower 15 m of the stratigraphic section, and the latest Blancan Virden LF occurs in the upper 20 m of the section. The Pearson Mesa fauna consists of 25 species: three land tortoises (*Gopherus* and two species of *Hesperotestudo*); box turtle (*Terrapene*); colubrid snake; bird; and 19 mammals. Age-diagnostic mammals from the Pearson Mesa LF include: the ground sloth *Paramylodon* cf. *P. garbanii*; the pocket gopher *Geomys persimilis*; the cotton rat *Sigmodon medius*; the three-toed horse *Nannippus peninsulatus*; the one-toed horses *Equus* cf. *E. cumminsii*, and *E. simplicidens*; and the peccary *Platygonus bicalcaratus*. The association of *Paramylodon* and *Nannippus* defines a restricted interval of time in the Blancan between the first appearance of South American immigrants (including *Paramylodon*) in the southwestern US at ~3.0 Ma and the extinction of *Nannippus* at ~2.2 Ma. Magnetostratigraphy further constrains the age of the Pearson Mesa LF, with five normally magnetized samples from the lower part of the section referred to the uppermost Gauss Chron (Chron 2An.1n; 2.58–3.04 Ma). Southwestern early late Blancan faunas (~2.6–3.0 Ma) correlative with Pearson Mesa include: Anapra, New Mexico; Wolf Ranch and 111 Ranch, Arizona; and Cita Canyon and Hudspeth, Texas. A 10-m-thick sedimentary breccia overlying the Pearson Mesa LF lacks fossils and may represent a hiatus. The Virden LF consists of 22 species: toad; large *Hesperotestudo*; *Terrapene*; colubrid snake; lizard; two birds; and 15 mammals. A latest Blancan age (~1.8–2.2 Ma) for the Virden LF is indicated by the presence of the dwarf cotton rat *Sigmodon minor* and the small camelid *Hemiauchenia gracilis*, both restricted to latest Blancan faunas, and the association of the glyptodont *Glyptotherium arizonae* with the coyote-like canid *Canis lepophagus*. Southwestern latest Blancan faunas correlative with Virden include: La Union, New Mexico, and Curtis Ranch and San Simon, Arizona.

BITE MARKS ON A SKULL OF *PSEUDOPALATUS MCCAULEYI* (ARCHOSAURIA: CRUROTARSI: PHYTOSAURIDAE) FROM THE UPPER TRIASSIC BULL CANYON FORMATION, EASTERN NEW MEXICO, *L. F. Rinehart*, larry.rinehart@state.nm.us, New Mexico Museum of Natural History and Science, 1801 Mountain Road NW, Albuquerque, New Mexico 87104; *A. B. Heckert*, heckertab@appstate.edu, Department of Geology, Appalachian State University, ASU Box 32067, Boone, North Carolina 28608; *S. G. Lucas*, and *D. C. Bond*, New Mexico Museum of Natural History and Science, 1801 Mountain Road NW, Albuquerque, New Mexico 87104

A 1.12-m-long brachyrostral phytosaur skull (NMMNH P-56187) from the Upper Triassic

Bull Canyon Formation of eastern New Mexico is assigned to *Pseudopalatus mccauleyi* based on its poorly preserved, but apparently depressed supratemporal fenestrae, its subtriangular squamosal process, and completely crested rostrum. The skull is obliquely flattened, exposing the left side of the face and skull roof. The lachrymal-nasal area, bounded by the external nares, antorbital fenestra (aofe), and orbit on the left side, is punctured by three large holes, one immediately dorsal to the middle of the aofe and two more (paired?) posterior to the first and approximately halfway between the aofe and the orbit. Based on size and shape, these holes appear to represent bite marks, probably from another (possibly conspecific) phytosaur. The three marks thus form an "L" and probably represent two teeth from one side of the biting animal's jaw and one from the other, although the orientation of attack is not clear. The larger holes may mark wounds inflicted by the large teeth in the "bulb" of a phytosaur snout, with the smaller injury attributed to a smaller, more posterior tooth. The edges of the holes are smooth and rounded, evidently having healed.

The tooth marks measure: (1) 27 x 10 mm, (2) 25 x 13 mm, and (3) 16 x 14 mm. The combination of elongate and approximately round punctures supports assignment of the bite mark to the ichnotaxon *Heterodontichnites hunti*. This is only the second bite mark on a phytosaur fossil of which we are aware. The other is in the palate of a large skull of *Redondasaurus bermani* (NMMNH P-31094) from the Redonda Formation of east-central New Mexico. This injury comprises three smaller (9–12 mm), approximately round punctures in a gently curved line that is 45 mm long. These punctures show healed edges and may have been self-inflicted. Thus, the *Pseudopalatus* bite mark is the first unambiguous evidence of a phytosaur suffering an attack from another phytosaur of which we are aware.

THE ROUSSEAU H. FLOWER INVERTEBRATE FOSSIL COLLECTION: CONSERVATION AND CURATION, *J. A. Spielmann*, New Mexico Museum of Natural History and Science, 1801 Mountain Road NW, Albuquerque, New Mexico 87104 and Department of Earth and Environmental Science, New Mexico Institute of Mining and Technology, Socorro, New Mexico 87801; *J. McDonnell, D. Traeger*, New Mexico Museum of Natural History and Science, 1801 Mountain Road NW, Albuquerque, New Mexico 87104; *A. B. Heckert*, Department of Geology, Appalachian State University, ASU Box 32067, Boone, North Carolina 28608; *S. G. Lucas,* New Mexico Museum of Natural History and Science, 1801 Mountain Road NW, Albuquerque, New Mexico 87104; and *P. M. Hester*, Bureau of Land Management, 435 Montano NE, Albuquerque, New Mexico 87107

Rousseau H. Flower (1913–1988), formerly of the New Mexico Bureau of Mines and Mineral Resources (NMBMMR), was one of the most important invertebrate paleontologists in the history of New Mexico geology. His prolific collecting and publishing established four orders, approximately 100 genera, and over 400 species of invertebrates, most of them cephalopods. Many of his specimens were collected from BLM-administrated lands in New Mexico and Texas. The extensive collection produced by Flower is one of the most important records of Paleozoic invertebrates in the country.

A major portion of this collection (later known as the Socorro or Flower collection) was given to the New Mexico Museum of Natural History and Science (NMMNH) by the NMBMMR in late 1993 and accessioned into the NMMNH collection in 1998. It represents one of the most extensive collections of Ordovician cephalopods in the country, if not the world. Unfortunately, the Socorro collection, with its ~10,000 specimens, was too large to tackle for many years. However, in 2004, one of us (ABH) initiated with two volunteers (JM and DT) the long process of going through the Socorro collection in order to catalog specimens and localities. This was accomplished by using a single ledger kept by Flower and his various publications to assign as much locality and taxonomic information to the specimens as possible. The locality information obtained from the ledger was transferred to GPS coordinates (UTMs) and entered into the NMMNH locality database, thus ensuring the data would be recorded for future research. The Socorro collection now represents a significant portion of the NMMNH geoscience collection, over 2,000 of the 56,000 cataloged specimens, including 351 holotypes, 10 topotypes, 155 paratypes, and 21 syntypes.

The process of cataloging is still ongoing, under the direction of the senior author in conjunction with other NMMNH staff. In 2007 the NMMNH was able to purchase, with BLM supported funds, five new collections cabinets to house the now curated Socorro collection. Finally, 15 yrs after the initial transfer these critically important fossils, once at risk, now have a permanent home where they will be kept for future research and display.

MOLDING AND CASTING A *REDONDASAURUS* (ARCHOSAURIA: PHYTOSAURIDAE) SKULL USING ELEMENTS FROM THREE DIFFERENT ANIMALS, *D. R. Ulibarri*, dwayne.ulibarri@state.nm.us, New Mexico Museum of Natural History and Science, 1801 Mountain Road NW, Albuquerque, New Mexico 87104

To produce a large (1.2-m-long) *Redondasaurus bermani* skull and jaw for the New Mexico Museum of Natural History and Science's Triassic exhibit hall, elements of three different animals had to be sculpted together. The skull (NMMNH P-31094) was missing its snout and lower jaw. A *Redondasaurus* snout (NMMNH P-25654) that was found nearby, but clearly belonging to a different animal, was sculpted onto the skull using Klean Klay. Photographs of the type skull of *Redondasaurus bermani* at the Carnegie Museum in Pittsburgh, Pennsylvania, were used to establish the correct length to width ratio for an accurate recreation of the complete skull. Because no high quality lower jaws of *Redondasaurus* were available for molding, a lower jaw from *Pseudopalatus mccauleyi* (NMMNH P-4256) was molded and sculpted to fit the skull. Approximately 200 teeth (NMMNH P-31096, P-17036, P-17026, P-44047) of *Redondasaurus* were molded in RTV silicone, cast in polyurethane, and glued into the original tooth sockets.

The right rear portion of the original skull was slightly flattened, and the right quadrate somewhat splayed out. In order to remove this distortion from the final product, the cast had to be drawn from the mold during the pre-cure stage and reshaped while the resin was still soft and pliable.

AN UPPER CRETACEOUS (LOWER CAMPANIAN) FEATHER FROM THE POINT LOOKOUT SANDSTONE, NORTHWESTERN NEW MEXICO, *T. Williamson*, thomas.williamson@state.nm.us, New Mexico Museum of Natural History and Science, 1801 Mountain Road NW, Albuquerque, New Mexico 87104; *B. S. Kues, G. S. Weissmann*, Department of Earth and Planetary Sciences, University of New Mexico, Albuquerque, New Mexico 87131; *T. A. Stidham*, Department of Biology, Texas A&M University, 3258 TAMU, College Station, Texas 77843; and *S. L. Yurchyk*, Department of Earth and Planetary Sciences, University of New Mexico, Albuquerque, New Mexico 87131

Fossils of Cretaceous feathers are extremely rare, especially from clastic sediments. Here we report on a partial pennaceous feather collected from the lower Campanian Point Lookout Sandstone of northwestern New Mexico (New Mexico Museum of Natural History locality L-7468). The feather is from a laterally discontinuous shale at the top of the Point Lookout Sandstone, a basal marine shoreline facies deposited during the R-4 regressive cycle. The shale contains cylindrical invertebrate burrows including *Ophiomorpha*, abundant plant fragments of conifers and angiosperms, and a sparse invertebrate fauna including the inarticulate brachiopod *Lingula* and the pelecypods *Caryocorbula* and *Nucula*. The flora and fauna of the shale unit suggest deposition in a quiet pond, probably on a delta-plain mud flat, that was close enough to the shoreline to receive marine water and allow influx of sparse marine invertebrates, but also rendered brackish by fresh-water runoff.

The partial pennaceous feather, University of New Mexico (UNM) 14742, is preserved on a bedding plane as either a carbonized trace or an autolithification. The feather is missing the basal barbs and the base of the rachis and calamus and has a preserved length of 12.6 mm and a maximum width of 6.2 mm. It possesses numerous barbs that are arrayed in symmetrical vanes. About three barbs per millimeter occur on each side of the rachis, and the bases of 25 barbs are preserved within each vane. Nine barbules per millimeter were counted along the distal side of one of the barbs on the left vane. The vanes decrease in width toward a rounded tip. Both vanes show gaps that indicate the barbs normally interlocked and so possessed differentiated distal and proximal barbules. Based on this morphology, UNM 14742 is a closed pennaceous feather (Stage IV) and a contour feather and can be referred to Maniraptora, a group that includes true birds and coelurosaur dinosaurs. It probably represents a bird.

POSTER SESSION 2—STRATIGRAPHY, STRUCTURE, AND MAPPING

PENNSYLVANIAN STRATIGRAPHY ON THE NORTHERN FLANK OF THE OSCURA MOUNTAINS, SOCORRO COUNTY, NEW MEXICO, *S. G. Lucas*, spencer.lucas@state.nm.us, Museum of Natural History and Science, 1801 Mountain Road NW, Albuquerque, New Mexico 87104; *K. Krainer*, Institute of Geology and Paleontology, University of Innsbruck, Innsbruck, A-6020, AUSTRIA; *L. F. Rinehart*, and *J. A. Spielmann*, New Mexico Museum of Natural History and Science, 1801 Mountain Road NW, Albuquerque, New Mexico 87104

The Pennsylvanian strata exposed on the northern flank of the Oscura Mountains are a classic section because M. L. Thompson used it as a key reference section in his 1942 monographic synthesis of the Pennsylvanian in New Mexico. This section is ~334 m thick, and we assign it to the Sandia, Gray Mesa, Atrasado, and Bursum Formations. The Sandia Formation is thin (~13 m), overlies Precambrian granite, and is mostly shale and sandy limestone. The lowest cherty limestone ledge marks the base of the overlying Gray Mesa Formation, which is ~162 m thick. Most of the Gray Mesa is limestone (63% of the section), the remainder is covered slopes (shale?), most of the limestones are cherty and numerous fusulinid packstones are present. The Atrasado Formation is ~124 m thick and includes (in ascending order) the Veredas, Hansonburg, and Keller groups of Thompson, names that should be abandoned. The facies ranges from siliciclastic sandstone and fine-grained conglomerate to bedded fossiliferous limestone of an open marine shelf to massive algal limestone of a mound facies formed just below wave base in quiet water in the photic zone. The formations named by Thompson work as local lithostratigraphic units at the member or bed rank. Thus, we recognize (in ascending order) the Adobe Member (33.5 m), Council Springs Bed (4.8 m), Burrego Member (16.4 m), Story Member (18.3 m), Del Cuerto Member (34.8 m), and Moya Member (16.5 m) of the Atrasado Formation. The Bursum Formation overlies the Atrasado Formation and is 35 m of marine limestone and red-bed clastics. Abo Formation red-bed siliciclastics overlie the Bursum Formation and are of presumed earliest Permian age. Fusulinids indicate that the Desmoinesian–Missourian boundary is in the upper Gray Mesa Formation, the Missourian–Virgilian boundary is ~ base of Del Cuerto Member, and the Wolfcampian (Newwellian) base is ~ base of Bursum.

LATE QUATERNARY DEVELOPMENT OF THE PECOS RIVER FLOODPLAIN, BITTER LAKE QUADRANGLE, NEW MEXICO, *D. J. McCraw*, djmc@nmt.edu, New Mexico Bureau of Geology and Mineral Resources, New Mexico Institute of Mining and Technology, Socorro, New Mexico 87801

The floodplain architecture of the Pecos River valley within the Bitter Lake quadrangle is comprised of: 1) basal late Pleistocene braided stream deposits; 2) distinct Holocene (2) and historic (2) meander belts; 3) backswamp or spring cienega deposits beneath older Pecos River terraces to the west; 4) thin alluvial veneers and karstic collapse depressions atop of Permian Seven Rivers Formation gypsum on the east; 5) a large, late Pleistocene braided fluviodeltaic fan complex of the Rio Hondo to the southwest; and 6) two early to middle Holocene Rio Hondo meander belts that prograded across the Pecos River floodplain below the confluence. Pecos River alluvium is light-reddish-brown, medium-grained quartzose sand and pebbly sand; gravel consists of sandstone, quartzite, chert, igneous rocks, and minor carbonates, except in backswamp areas, which contain silt, clay, and gypsite. South of the Rio Hondo confluence, Pecos River alluvium intermixes with Rio Hondo alluvium, which is dark yellowish brown in color, and contains abundant porphyritic igneous and carbonate gravel. Floodplain alluvium thickness decreases from a maximum of around 45 m along the western margin to <1 m to the east.

Large Pleistocene-age braid plains are exposed on the northern and southern edges of the quadrangle. These resulted from steeper gradients, easily erodible banks, and a much greater variability in discharge. At the end of the Pleistocene, vast quantities of sediment-rich, glacial meltwater flowing out of the Sacramento Mountains down the Rio Hondo built a vast fluviodeltaic fan out onto the Pecos River floodplain. This initiated meandering atop of the braid plain upstream of the fan in response to a decrease in gradient. A segment of this initial meander belt, preserved north of Bitter Lake, likely carried flows concomitantly with braided channels to the east during the early Holocene. The Rio Hondo fan pushed the Pecos River eastward into collapse depressions at this time as well, which allowed the Rio Hondo to build meander belts across the Pecos River braid plain to the south during the early to middle Holocene. Pecos River meander morphometry clearly distinguishes late Holocene to historic meander belts from those of the early Holocene, as meander amplitudes and wavelengths greatly increase up to a maximum 2 km wide meander with a wavelength of 1.6 km, recorded from a 1940-vintage aerial photograph. Extensive man-made meander cutoffs were constructed in the 1950s and 1960s, resulting in a modern channel that exhibits few, small meanders that are typically locked into bedrock or former braided channel courses.

SUMMARY OF THE GEOLOGY, GEOCHRONOLOGY, AND GEOCHEMISTRY OF THE ABIQUIU 1:24,000 QUADRANGLE AND CONTIGUOUS AREAS, NORTH-CENTRAL NEW MEXICO, *F. Maldonado*, fmaldona@usgs.gov, *D. P. Miggins*, and *J. R. Budahn*, U.S. Geological Survey, MS 980, Denver Federal Center, Denver, Colorado 80225

The Abiquiu quadrangle is located within the Abiquiu embayment, a shallow, early extensional basin of the Rio Grande rift near the eastern margin of the Colorado Plateau–Rio Grande rift in north-central New Mexico. The geology, newly determined $^{40}Ar/^{39}Ar$ dates and geochemical data, and a newly discovered low-angle fault are described. Rocks exposed in the quadrangle and contiguous areas include continental Paleozoic and Mesozoic strata of the Colorado Plateau, Cenozoic basin-fill deposits, and Tertiary volcanic rocks. Paleozoic units include the Late Pennsylvanian to Early Permian Cutler Group, undivided. Mesozoic units are, in ascending order, the Upper Triassic Chinle Group, undivided, and Middle Jurassic Entrada Sandstone and Todilto Limestone Member of the Wanakah Formation. Cenozoic rocks include the Eocene El Rito Formation, newly named Oligocene conglomerate of Arroyo del Cobre, Oligocene–Miocene Abiquiu Formation, and Miocene Chama–El Rito and Ojo Caliente Members of the Tesuque Formation of the Santa Fe Group. Intrusive and extrusive rocks include the basaltic dike of Red Wash Canyon (Miocene), Cerrito de la Ventana basaltic dike (Miocene), Lobato Basalt (Miocene), Sierra Negra Basalt (Miocene–Pliocene), Servilleta Basalt (Pliocene), El Alto Basalt (Pliocene), and dacite of the Tschicoma Formation (Pliocene). Quaternary deposits consist of ancestral axial and tributary Rio Chama deposits, landslide colluvium, and Holocene floodplain alluvium, fan and pediment alluvium. Faults in the quadrangle are Tertiary normal faults that displace rocks toward the rift and minor Mesozoic thrust faults. A low-angle fault, referred to here as the Abiquiu fault, separates an upper plate composed of the transitional zone of the Chama–El Rito and Ojo Caliente Members of the Tesuque Formation from a lower plate consisting of the Abiquiu Formation or the conglomerate of Arroyo del Cobre. The upper plate is distended into blocks that range from about 0.1–3.5 km long that may represent a larger sheet that has been fragmented and partly eroded.

New $^{40}Ar/^{39}Ar$ ages for intrusive and extrusive rocks include the following: (1) El Alto Basalt, 2.82 ± 0.05 Ma (isochron age), 2.86 ± 0.05 Ma (plateau age); (2) Servilleta Basalt, 3.45 ± 0.06 Ma (isochron age), 3.69 ± 0.45 Ma (plateau age); (3) Sierra Negra Basalt, 5.44 ± 0.06 Ma (isochron age), 5.56 ± 0.12 Ma (plateau age); (4) Lobato Basalt/dike, 10.05 ± 0.07 Ma (isochron age), 10.11 ± 0.13 Ma (plateau age); 9.57 ± 0.11 Ma (isochron age), 9.51 ± 0.21 Ma (plateau age); and 7.83 ± 0.07 Ma (isochron age), 7.87 ± 0.10 Ma (plateau age); (5) Cerrito de la Ventana basaltic dike, 19.22 ± 0.30 Ma (isochron age), 19.58 ± 0.09 Ma (weighted mean age); and (6) basaltic dike of Red Wash Canyon, 19.63 ± 0.40 Ma (isochron age). In-progress geochemical analyses by XRF (major element) and INAA (trace element) will help resolve the geochemical evolution for these rocks.

PRECAMBRIAN BASEMENT OF THE DEFIANCE UPLIFT—POSSIBLE CORRELATION TO THE UNCOMPAHGRE QUARTZITE AND INFLUENCES OF BASEMENT FABRIC ON LATER TECTONISM, *B. Dixon*, and *K. E. Karlstrom*, Department of Earth and Planetary Sciences, University of New Mexico, Albuquerque, New Mexico 87131

The Defiance uplift is an asymmetrical basement-cored, fault-bounded uplift of Ancestral Rockies and Laramide age located entirely on the Navajo Nation in northeast Arizona and northwest New Mexico. Small outcrops of Precambrian rocks occur in four canyons (Blue Canyon, Meadow Wash, Fork Canyon, and Hawk Canyon) that drain the east side of the uplift (total outcrop area of < 1 km^2). Blue Canyon and Meadow Wash contain quartzites, with no contact relationships exposed. These are medium-grained quartz arenites with well-preserved ripple marks and crossbeds, lithologically very similar to the Uncompahgre Quartzite of southwest Colorado exposed about 200 km to the northeast. Fork and Hawk Canyons contain thinly laminated, low-grade argillite and grayish-green, highly altered greenstone (metabasalt). These are intruded by several different granitoids: fine-grained granite (probably 1.7–1.65 Ga), altered granite porphyry, megacrystic granite (likely 1.4 Ga), and aplite and pegmatite dikes. Based on correlation of aeromagnetic highs with granites encountered in drill holes, the basement of the uplift appears dominated by granitoids. U-Pb zircon ages on basement xenoliths from the nearby Tertiary diatremes (Condie et al. 1999) include both Paleoproterozoic granites (1,725–1,603 Ma) and Mesoproterozoic granites (1,453–1,381 Ma). The assemblage and ages of Proterozoic rocks are thus similar to the Yavapai–Mazatzal transitional boundary zone elsewhere in New Mexico. Structure contour and isopach maps show a gentle westward dip of the Great Unconformity accompanied by westward thickening of Paleozoic rocks (Werme 1981), indicating an Ancestral Rockies history. The faulted east side, coincident with East Defiance monocline, is likely Laramide in age, with possible right strike-slip movement (Kelley 1955). Evidence for basement-controlled localization of Phanerozoic structures includes parallelism of a prominent northeast-trending aeromagnetic high and the Nazlini northeast-trending fault and deflection of the East Defiance monocline at the same basement anomaly.

AMS DATA BEARING ON THE DEFORMATIONAL HISTORY OF THE PROTEROZOIC BASEMENT IN THE LAS VEGAS AREA, SOUTHERN SANGRE DE CRISTO MOUNTAINS, NEW MEXICO, *L. Garcia, M. S. Petronis, J. Lindline*, Department of Natural Sciences, New Mexico Highlands University, Las Vegas, New Mexico 87701; and *J. W. Geissman*, Department of Earth and Planetary Sciences, University of New Mexico, Albuquerque, New Mexico 87131

Models for the deformational history of deep- to middle-crustal rocks rely heavily on the documentation of rock structures, which are not always detectable in the field. Anisotropy of magnetic susceptibility (AMS) analysis allows for the evaluation of non-visible petrofabrics as it can detect structural anisotropies of less than 1% in rock samples. We conducted anisotropy of magnetic susceptibility (AMS) analysis on Proterozoic basement rocks west of Las Vegas, New Mexico, in an attempt to better document and interpret deformation features. We studied medium-grade gneisses cropping out along County Road 65 in the Gallinas Canyon, which dissects a portion of the Hermit's Peak batholithic complex. Rock types include quartzofeldspathic gneisses, biotite schists, and laminated amphibolites. The gneisses show intense penetrative deformation defined by a strong steeply dipping, northeast-trending axial planar foliation. Minor macroscopic linear structures, including isoclinal fold hinges and prismatic mineral alignments, plunge moderately to the southwest. Oriented AMS samples, typically eight to twelve samples per site, were collected from twelve sites throughout the canyon. All samples were analyzed on an AGICO static KLY-4S Magnetic Susceptibility/Anisotropy System at the University of New Mexico Rock Magnetism Laboratory in order to characterize the magnetic mineralogy and magnetic fabric of the rocks. Preliminary rock magnetic data indicate that the dominant magnetic phase in most specimens is a ferri/ferromagnetic oxide (magnetite, maghemite) as demonstrated by an average bulk susceptibility of 8.5 x 10^{-3} SI. Additional rock magnetic experiments are being conducted to further assess the magnetic mineralogy. The AMS fabric data are consistent with the macroscopic structural features, particularly the lineations, which were visible at only a fraction of the study sites. We propose that our petrofabric and rock magnetic data reflect the dominance of northwest-southeast contractional deformation and southwest-northeast extension in the assembly history of the continental lithosphere during the Proterozoic. Our study shows that AMS petrofabric analysis is a simple yet powerful tool for obtaining high-quality orientation data from crystalline rocks for which visible rock structures are lacking or tenuous.

PRELIMINARY PETROLOGIC ANALYSIS OF PROTEROZOIC HERMIT'S PEAK BATHOLITH ORTHOGNEISSES, NORTH-CENTRAL NEW MEXICO, *J. Lindline*, lindlinej@nmhu.edu, and *R. Trevizo*, roberttrevizo@hotmail.com, Department of Natural Sciences, New Mexico Highlands University, Las Vegas, New Mexico 87701

We report preliminary petrologic results on mafic and felsic orthogneisses of the Hermit's Peak batholith, a Proterozoic plutonic-metamorphic complex in the southern Sangre de Cristo Mountains northwest of Las Vegas, New Mexico. We studied rocks that crop out along County Road 65 in the Gallinas Canyon, which dissects a portion of the batholith. Major rock types include quartzofeldspathic gneisses and laminated amphibolites. The felsic gneisses contain microcline + albite + quartz ± biotite in a medium- to coarse-grained anhedral granular texture. Muscovite is rare and often secondary in origin. The felsic gneisses commonly display quartz ribbons and microcline porphyroclasts and are interpreted as metagranites. They have Rb-(Y+Nb) and Nb-Y variations indicative of volcanic-arc granites. The mafic gneisses contain hornblende + plagioclase + quartz + titanite ± epidote and display a fine- to medium-grained subhedral granular to idioblastic texture. They show igneous differentiation trends on Niggli variation diagrams and are interpreted as metabasalts. They plot as island arc tholeiites and ocean island arc basalts on tectonic discriminant diagrams. The granite gneisses and amphibolite gneisses are interpreted as part of an arc system that was accreted to North America during the assembly history of the continental lithosphere. The bimodal nature of igneous activity suggests a magmatic rift may have been operative during their formation. We continue to analyze our data to see if differentiation of the proposed rift setting (juvenile or continental) is possible and test whether our data are consistent with an arc accretion model or if an expanded model including crustal extension is required.

PRELIMINARY INTERPRETATION OF SIX YEARS OF TILTMETER MOTIONS ABOVE THE FLANKS OF THE SOCORRO MAGMA BODY, CENTRAL RIO GRANDE RIFT, *D. W. Love*, dave@gis.nmt.edu, *B. D. Allen, R. M. Chamberlin*, New Mexico Bureau of Geology and Mineral Resources, New Mexico Institute of Mining and Technology, Socorro, New Mexico 87801; and *W. C. Haneberg*, Haneberg Geoscience, 10208 39th Avenue SW, Seattle, Washington 98146

Three shallow (3 m) biaxial borehole tiltmeters in place around the margins of the uplift above the Socorro Magma Body (SMB) since 2002 show near-surface ground motions at several temporal scales. Two tiltmeters are located in narrow grabens of the Rio Grande rift about 15–20 km north and south of the center of historic uplift near San Acacia. The north station is in a symmetrical graben; it may be more responsive to magmatic tilt than tectonic tilt. A third tiltmeter at Silver Creek is located on a west-tilted rift block about 15 km west of San Acacia, where magmatic uplift and tectonic tilt should be additive.

The tiltmeters (Applied Geomechanics model 722) with selectable gain and output range of ± 2500 mV are set at high-gain resolution of ± 0.1 microradians over a range of ± 800 microradians. Readings of north-south and east-west tilts, as well as temperatures, are taken every 30 seconds and the average recorded every 20 minutes. The western datalogger also records local precipitation. The tiltmeter records show: 1) earth-tide cycles of 10ths of microradians on the order of two per day, 2) surface waves of distant moderate-to-large earthquakes that affect tilt averages over 20–40 minutes, 3) 10- to 20-day abrupt excursions following large precipitation events, 4) 10–14 month wavelike variations perhaps related to lagging seasonal temperature gradients at depth of burial, 5) a few abrupt excursions of uncertain origin, and 6) multi-year long-term changes in average tilts, both in direction and magnitude. The last type of tilting may be related to transient motions of either structural blocks within the Rio Grande rift above the SMB, and/or " heavy breathing" of a smaller shallow magma body as suggested by GPS data collected since 2003 (Newman et al. 2004). "Heavy breathing" is a common metaphor for alternating magma chamber inflation and deflation over periods of several years or decades, as observed in the vicinity of several "restless" Quaternary calderas.

When viewed together in a relative and qualitative sense, averaged tiltmeter data for stations north and west of San Acacia suggest a period of magmatic uplift (inflation) was occurring from the fall of 2002 to the summer of 2004. Tilting dominantly toward San Acacia from the summer of 2004 to the fall of 2006 may represent a period of magmatic deflation. Inflation may now be ongoing.

The apparent motions of local fault blocks are clearly not unidirectional, and when viewed in an absolute sense some patterns seem counter-intuitive. Clearly, longer-term records of tilt and perhaps more tiltmeters are warranted. Tiltmeter data may ultimately be temporally correlated to surface motions currently being measured by nearby continuous GPS stations and new INSAR data.

INCISION HISTORY OF THE RIO SALADO AND IMPLICATIONS FOR UPLIFT HISTORY OF THE JEMEZ MOUNTAINS, *T. Sower*, tsower@unm.edu, *D. Rose-Cose, K. E. Karlstrom, L. J. Crossey, Y. Asmerom*, and *V. Polyak*, Department of Earth and Planetary Sciences, University of New Mexico, Albuquerque, New Mexico 87131

The Rio Salado, a tributary to the Jemez River, has a suite of strath terraces that record the incision history of the south and west sides of the Jemez/Nacimiento Mountains. The goal of the project is to map Quaternary units, establish the heights of terraces, correlate Rio Salado and Rio Jemez terraces, and evaluate the incision history of the southern flank of the Jemez Mountains to evaluate possible surface uplift due to magmatic inflation associated with the Jemez lineament and/or Jemez volcano.

Straths on the south flank of the Nacimiento uplift are cut into the Petrified Forest Member of the Chinle Formation. They are mantled by thin (1–10 m) cobble to boulder gravels with basement lithologies that were sourced in the nearby Nacimiento Mountains. Nine strath terraces were mapped, with strath heights above the modern channel as follows: Qt1 2 m, Qt2 2–7 m, Qt3 20 m, Qt4 30 m, Qt5 44 m, Qt6 60 m, Qt7 113 m, Qt8 140–147 m, Qt9 164–183 m. These terraces can be correlated along the south side of the river for 9.4 km from the confluence with the Jemez River, west to the Nacimiento fault. Correlation is based on elevation above the channel and nature of the thin gravel and travertine fill. Gravels are variably cemented and overlain by travertine. Travertine springs are present near the modern floodplain Qt0/Qt1 and provide a modern analog for the higher travertine-cemented gravels. The Agua Zarca Sandstone Member of the Chinle Formation forms the dip slope of the southern Nacimiento and, together with fault conduits for deeply sourced waters, forms the plumbing system for the travertine spring waters. Accompanying incision, the position of the active springs has migrated north down the dip slope synchronous with northward migration of the river channel and retreat of cliffs of Entrada and Todilto Formations. Dates on the travertine were obtained by U-Series methods on three of the terraces giving the following incision rates: Qt3/4 is 30.6 ± 0.3 ka (36 m/31 ka = 116 m/

Ma); Qt8 is 415 ± 0.2 ka (140 m/415 ka = 337 m/Ma); Qt9 is outside U-Series range (164 m/>500 ka = <328 m/Ma).

BURIED LANDSCAPES—PALEOTOPOGRAPHY OF THE CERRO TOLEDO INTERVAL, BANDELIER NATIONAL MONUMENT, JEMEZ MOUNTAINS VOLCANIC FIELD, *E. P. Jacobs*, perkijacobs@gmail.com, 3007 Villa Street, Los Alamos, New Mexico 87544

Prior landscapes preserved between eruptive cycles of the Jemez volcanic field form subsurface pathways that influence the flow of contaminants and ground water. Knowledge of how fluids move from the surface through perched zones to the aquifer is still developing. This study looks at the prior landscape "sealed" between two major ash flows (Otowi and Tshirege Members of the Bandelier Tuff at 1.6 and 1.2 Ma), within Bandelier National Monument (BNM). The ~380,000 yr interval between the Bandelier eruptions, informally termed the Cerro Toledo interval, contains as much as 120-m-thick deposits that provide favorable settings for perched zones. Windows into this landscape are exposed in Frijoles and Alamo Canyons, two narrow, deeply incised canyons that lie within the northern section of BNM. Structure contour and isopach maps derived from field observations of exposed contacts in BNM are combined with existing geologic surface and drill-hole data for the southern part of Los Alamos National Laboratory to provide a glimpse of the topography that developed before eruption of the Tshirege Member. The nonwelded Otowi Member was easily eroded, resulting in a landscape characterized by rolling hills with gentle gradients. Episodic eruptions of plinian ash and erosion of the Sierra de los Valles, accompanied by possible seismic shaking during the collapse of a portion of Rabbit Mountain, resulted in pulses of sediment that periodically overwhelmed developing drainage systems. Regional base level was controlled by the ancestral Rio Grande, whose location shifted in response to silicic volcanism from the Jemez Mountains to the west, mafic flows from the Cerros del Rio volcanic field (~3.0–1.1 Ma) to the east, as well as probable seismic activity within the rift. The mafic flows created a resistant tableland that provided local knickpoints for streams draining the Otowi headlands, allowing broad washes to form adjacent to the master stream. In addition, continuing eruptive activity, occasional landslides, earthquakes, and undercutting of the ancestral Rio canyon formed ephemeral impoundments that may have temporarily raised base level along particular reaches influencing rates of tributary drainage network development and affecting where large, episodic outflows of sediment would have been deposited.

POSTER SESSION 3—HYDROLOGY, HYDROGEOCHEMISTRY, CLIMATE, AND MICROBIOLOGY

RED RIVER INCISION RECORDED IN SUPERGENE JAROSITE, TAOS COUNTY, NEW MEXICO, *K. E. Samuels,* ksamuels@nmt.edu, *A. R. Campbell*, Department of Earth and Environmental Science, New Mexico Institute of Mining and Technology, Socorro, New Mexico 87801; *V. W. Lueth*, and *L. Peters*, New Mexico Bureau of Geology and Mineral Resources, New Mexico Institute of Mining and Technology, Socorro, New Mexico 87801

Supergene jarosite, a pyrite weathering product, preserved in ferricretes and weathered veins in the Red River valley (RRV), New Mexico, records the timing of alteration scar formation and compositions of pyrite-oxidizing fluids. Weathering and subsequent erosion of pyrite-enriched hydrothermally altered bedrock along the Red River, a Rio Grande tributary in Taos County, New Mexico, forms alteration scars. $^{40}Ar/^{39}Ar_{(jarosite)}$ dates range from 4.45 ± 0.70 Ma at the highest elevations of a weathering profile to 0.31 ± 0.23 Ma at lower elevations in a scar ferricrete. Although supergene jarosite does not always yield well-behaved plateaus with precise $^{40}Ar/^{39}Ar_{(jarosite)}$ ages, RRV jarosite ages consistently preserve "inverse superposition" relationships typical of incised landscapes. Alteration scar formation probably began ~4.5 Ma, which is consistent with weathering dates found by previous workers at nearby Creede, Colorado.

$\delta^{34}S_{jarosite}$ values (-12.1 to -0.8‰) that overlap $\delta^{34}S_{pyrite}$ (-13.6 to +2.7‰) and $\delta^{18}O_{(SO4)}$ that range from -4.6 to +2.3‰ confirm that RRV jarosite formed from supergene alteration of pyrite rather than hypogene fluids. As at Creede, Colorado, $\delta D_{jarosite}$ decreases in younger samples and may provide a continental climate record. However, this trend toward isotopically lighter fluids is not reflected in the narrow $\delta^{18}O_{(SO4)}$ range.

The average RRV alteration scar incision rate calculated based on elevation differences between stranded, dated ferricretes and alteration scar drainages is 77 m/m.y. This rate is consistent with published incision rates for the Rio Grande in northern New Mexico. Incision rates suggest that alteration scar erosion, which began when the Rio Grande had its headwaters in the RRV, began in response to base level changes in the Rio Grande as it became an integrated stream as far south as northern Mexico during the Pliocene.

^{40}AR/^{39}AR GEOCHRONOLOGICAL ANALYSIS OF MINNA BLUFF, ANTARCTICA—EVIDENCE FOR PAST GLACIAL EVENTS WITHIN THE ANTARCTIC CRYOSPHERE, *A. F. Fargo*, Department Earth and Environmental Science, New Mexico Institute of Mining and Technology, Socorro, New Mexico 87801; *W. C. McIntosh* and *N. W. Dunbar*, Department Earth and Environmental Science, New Mexico Institute of Mining and Technology, Socorro, New Mexico 87801 and New Mexico Bureau of Geology and Mineral Resources, Socorro, New Mexico 87801

The history and chronology of the Minna Bluff volcanic peninsula provides insight into past dynamics of the Ross Ice Sheet. Twenty-five samples of volcanic rock from different elevations on Minna Bluff have been dated using $^{40}Ar/^{39}Ar$ geochronology. When volcanoes interact with glacial ice the resulting lithofacies can provide useful information on ice thickness that can be used to interpret ice-sheet history. Datable volcanic rocks that bracket obvious glacial unconformities also provide information about glacial history. This information can be combined with data from the ANDRILL marine core to help determine ice-sheet chronology for the Miocene in the McMurdo Sound region.

Prior K/Ar dating of the southeastern exposures at Minna Bluff yielded dates ranging from 11 to 7.26 Ma and suggested that the southern tip of the bluff represents the oldest eruptions. New $^{40}Ar/^{39}Ar$ results from sanidine and amphibole mineral separates and groundmass concentrates, show older ages of 11.67 ± 0.19 Ma in the northern end of Minna Hook (the eastern end of the 50-km-long bluff) and the youngest age of 8.28 ± 0.17 Ma from one of the stratigraphically highest lava domes on Minna Hook.

A prominent glacial unconformity, which probably represents either overriding by the Ross Ice Sheet or formation of localized glaciers on the bluff, separates the lower volcanic section (dominated by basanite flows and breccias) from the central volcanic section (dominated by trachyte domes and secondary basanite flows). Multiple pairs of samples were collected from both above and below this unconformity in order to best constrain the period of glacial erosion. The youngest age from beneath the unconformity is 9.74 ± 0.07 Ma and the oldest age above the unconformity is 9.53 ± 0.07 Ma. This leaves between 350,000 and 70,000 yrs (allowing for errors at two sigma) for the glacial erosion to have taken place.

AQUEOUS GEOCHEMISTRY OF THE SPRINGS AND WELLS OF THE SEVILLETA NATIONAL WILDLIFE REFUGE—EVALUATING HYDROLOGIC PATHWAYS AND MICROBIOLOGY, *A. J. Williams*, awill7@unm.edu, *L. J. Crossey,* and *K. E. Karlstrom*, Department of Earth and Planetary Sciences, University of New Mexico, Albuquerque, New Mexico 87131

Both ground water and surface water are important sources for many metropolitan and agricultural communities along the Rio Grande corridor. Both high salinity and trace element concentrations are regionally important in impairing water quality. Although these waters are dominated volumetrically by meteoritic sources, recent research has revealed the widespread presence of volumetrically small, but geochemically important, deep fluid sources. These "endogenic" waters have been associated with springs issuing along rift-bounding faults in central New Mexico. This study reports new geochemical data from springs and ground waters in a cross-rift transect located in the Sevilleta National Wildlife Refuge and evaluates contributions from endogenic fluids. This transect extends from the Colorado Plateau on the west to the Great Plains on the east and includes springs along deep rift-bounding faults. This transect is also strategically located at the intersection of the Albuquerque and Socorro Basins, a structurally complex zone that appears to coincide with longitudinal changes in the Rio Grande surface water as reported in previous research.

Results indicate the interaction of three distinct hydrochemical facies: the first is a Na-Cl/SO_4 composition that consisted of the San Acacia pools, Rio Salado Springs, and the Rio Salado. The second, with a mixed cation-HCO_3 rich composition, consisted of the San Lorenzo Springs. The third, with a Ca/Mg–Cl/SO_4 composition, consisted of Cibola and Milagro Springs. We interpret these results in light of other regional ground water surveys and evaluate mixing models to explain the observed variations. Ongoing trace element analysis will allow for further testing of hydrologic mixing models.

GEOMICROBIOLOGY AND GEOCHEMICAL ENERGY FOR MICROBIAL METABOLISM IN CO_2-RICH SPRINGS OF THE TIERRA AMARILLA ANTICLINE, NEW MEXICO, *B. Cron*, b1985@unm.edu, Department of Biology, University of New Mexico, Albuquerque, New Mexico 87131; *L. J. Crossey*, Department of Earth and Planetary Sciences, University of New Mexico, Albuquerque, New Mexico 87131; and *D. Northup*, Department of Biology, University of New Mexico, Albuquerque, New Mexico 87131

Deep-sea hydrothermal vents and volcanic environments are a consequence of tectonic forces and fluid circulation near Earth's surface. Along the Tierra Amarilla anticline there are CO_2-rich mound springs that are also a consequence of interactions between deeply sourced ("endogenic") fluids and the extensional character of Earth's surface.

Archaeal communities similar to those found in Yellowstone National Park are known to utilize chemical species within the Tierra Amarilla anticline for metabolic processes. In this study we prepared oligotrophic media to culture microorganisms from both water and iron and sulfide-rich muds at the Tierra Amarilla anticline. We also sampled the springs for gas and water chemistry and established an analytical geochemistry dataset. This dataset provided us with useful thermodynamic constraints used in a geochemical computer code. The values from the computer code were then used to build a comprehensive list of potential metabolic reactions. We were able to predict energy available to fuel specific fungal and bacterial species found at the Tierra Amarilla site.

There is a flora of microbial life in these springs, and knowledge of the microbial bioenergetics in these systems is limited. By establishing how this location acts thermodynamically, we can come one step closer to defining the relationship between microbial and geochemical interactions in extreme environments by providing pertinent information that will help predict microbial growth parameters in other CO_2-rich springs.

SOIL GEOMORPHIC PATTERNS AND GRASSLAND RESISTANCE AT THE JORNADA BASIN LTER SITE, *D. M. Rachal*, D.Rachal@nmsu.edu, *H. C. Monger*, Department of Plant and Environmental Sciences, New Mexico State University, Las Cruces, New Mexico 88011; and *D. Peters*, U.S. Department of Agriculture, Agricultural Research Service, Jornada Basin LTER, Las Cruces, New Mexico 88011

Geomorphic properties, such as elevation, slope gradient, and orientation, are fundamental elements of the landscape that play a large role in the persistence of desert grasslands. Microclimatic variations created by these landform elements can control physical and chemical weathering rates of parent material. Topographic location (e.g. run-on vs. run-off position) can control the redistribution of this weathered material, which can influence the movement of nutrients and sediments by wind and water throughout an ecosystem. Over time, the process of erosion and sedimentation differentiates the landscape into individual soil units that vary in age, physical, and chemical composition. Upon these soil-geomorphic entities, isolated patches of grasslands can be found in the Jornada Basin, New Mexico. These grass patches are resistant against the transition from semiarid, perennial grasslands to a shrub dominated ecosystem that began within the Jornada Basin 150 yrs ago. The survival of these remnant grasslands is strongly influenced by vegetation-soil-landform relationships. Therefore, the soil-geomorphic properties of a specific landscape can provide a stronghold for grass species to resist and survive the detrimental effects of desertification, thus, producing the isolated grass patches that are observed today in the Jornada Basin.

ASPECT RELATED MICROCLIMATE'S EFFECTS ON SOIL-FORMING PROCESSES, HILLSLOPE EVOLUTION, AND VEGETATION DISTRIBUTION IN A SEMIARID WATERSHED, SEVILLETA NATIONAL WILDLIFE REFUGE, NEW MEXICO, *D. Gaugler*, dgaugler@unm.edu, Department of Earth and Planetary Sciences, University of New Mexico, Albuquerque, New Mexico 87131

North-south hillslope asymmetry is exhibited in a drainage basin incised into the pediment and associated alluvium of the Los Pinos Mountains. Microclimate variations with aspect and slope appear to be related to hillslope morphology, and variations in soil development, weathering, and vegetation cover may lead to differences in landscape evolution. To test this hypothesis, catenas are being examined at several stages of hillslope evolution from initial incision to a mature hillslope. Here the types and rates of weathering of the Permian limestone, sandstone, and mudstone of the Yeso and Abo Formations are apparently related to moisture availability. North-facing slopes, covered by juniper savannah, are steeper and transport-limited with deeper weathering profiles in all bedrock types, and have more extensive soil development including carbonate and gypsum accumulation. South-facing slopes, covered by creosote desert shrubland, are divided into segments by outcropping resistant bedrock units that act as local base level controls, with segments being either transport or weathering limited depending on facies. Investigations have suggested that feedbacks between weathering, soil formation, vegetation cover, and hydraulic properties have enhanced the differences in slope morphology over time.

RELATIONSHIPS BETWEEN TEMPORAL VARIATIONS IN GROUND WATER CHEMISTRY AND MICROMETEOROLOGICAL FLUXES ALONG THE MIDDLE RIO GRANDE OF NEW MEXICO, *S. Teet*, *L. J. Crossey*, Department of Earth and Planetary Sciences, University of New Mexico, Albuquerque, New Mexico 87131; *J. Cleverly*, and *J. Thibault*, Department of Biological Sciences, University of New Mexico, Albuquerque, New Mexico 87131

It is important to know the chemical properties of ground water, particularly when it is a primary source of consumed water as is the case in the Middle Rio Grande of New Mexico (MRG). Many aspects of this unique system have been studied including depth, spatial, and even some temporal variability. More needs to be understood, however, about how the physical and chemical properties of ground water in the MRG change on a temporal scale, particularly at high resolution as affected by exogenic factors. Factors such as evapotranspiration (ET) and irrigation may be affecting ground water chemistry diurnally but cannot be quantified because there are little data to look at for correlation on such time scales.

For this study, measurements were made during baseline conditions (in winter months when ET and irrigation for agriculture were not present) of DO, conductivity, pH, and water temperature for approximately one month each at three different sites along the Rio Grande using a Sonde 600 SLM (YSI) logger. These sites were chosen because they already have established 3-Dimensional Eddy Covariance systems that include several meteorological monitoring instruments as well as some for soil and water table measurements. Then the water chemistry data were analyzed and compared with the other site data to look for relationships in temporal changes of the measurements. This included comparisons of air and ground water temperature and water chemistries to precipitation and other physical variables. The result is a baseline dataset to look at further relationships during the growing season when ET is significant and water is manipulated for anthropogenic uses.

SINKHOLES IN SOUTHEAST NEW MEXICO—PROFILING THE GEOCHEMICAL, HYDROLOGICAL AND MICROBIAL CHARACTER OF SINKS ALONG THE PECOS RIVER AT BITTER LAKE NATIONAL WILDLIFE REFUGE, ROSWELL, NEW MEXICO, *Z. E. A. Premo*, and *L. J. Crossey*, Department of Earth and Planetary Sciences, University of New Mexico, Albuquerque, New Mexico 87131

Bitter Lake National Wildlife Refuge in southeastern New Mexico was established in 1937 to preserve the habitat of migratory waterfowl and to protect wetlands surrounding the Pecos River near Roswell, New Mexico. Such wetlands have developed around a series of playa lakes, water-filled sinkholes (sinks), and surface springs. These spring systems are threatened by regional climatic conditions in addition to direct anthropogenic influences such as ground water development. The goal of this project is to characterize the water chemistry of sinks at the refuge and identify hydrologic pathways that maintain these sinks. In addition, these efforts will be used to supplement ongoing biological research activities at the New Mexico State University (ichthyology) and University of New Mexico (entomology). In particular, this research will identify the presence of specific chemical components within the water that can be used as tracers to investigate ground water flow, pollution implications, and sources of accumulated toxins in biota tissues.

Water chemistry for a subset of approximately 20 sinks throughout the northern portion of the refuge is presented, and results are compared with existing datasets. Preliminary measurements indicate pH ranges of 7.14–8.97 and conductivity ranges of 8.58–106.6 mS/cm; such parameters can vary widely between sinks only meters apart. An additional component of this project involves developing procedures to monitor the subsurface chemistry at high temporal resolution for extended time periods to assess the system sensitivity to atmospheric and seasonal changes. In order to investigate microbial activity, sediment and water will be cultured by inoculating microbial-specific media, as well as filtering water to obtain DNA; the aim is to identify and isolate anaerobic microbial activity throughout the water column. Microbial communities are essential primary producers supporting the complex and unique ecosystems that have developed within individual sinks.

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