NEW MEXICO GEOLOGICAL SOCIETY SPRING MEETING

Friday, April 16, 2010

Macey Center, 801 Leroy Place
New Mexico Tech Campus
Socorro, NM 87801

Table of contents

Schedule of events...1
Abstracts, arranged alphabetically by first author............................5

NMGS Executive Committee

Past-President:	Kate Zeigler
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Technical Program Chair:	Dan Koning
Registration Chairs:	Kitty Pokorny and Connie Apache
Publicaton Chairs:	Claudia Lewis and Shari Kelley
On-site registration:	Connie Apache
Oral session chairs:	Dan Koning, Lewis Land, Talon Newton, Spencer Lucas, Shari Kelley, and Kate Zeigler

Schedule of Events – NMGS Annual Spring Meeting, April 16, 2010
Registration 7:30 a.m. to Noon, Macey Center, NM Tech

Session 1: Geology of the Sacramento Mountains and Tularosa Basin –Auditorium

Chair: Dan Koning

8:15-8:20 WELCOME AND INTRODUCTION

8:20-8:40 *KONING, D.J.*
COMPARISON OF ALLUVIAL FAN GEOMORPHOLOGY, SEDIMENTATION, AND EROSION ALONG THE EASTERN MARGIN OF THE TULAROSA BASIN, NEW MEXICO

8:40-9:00 *KELLEY, S.A., KONING, D.J., KEMPTER, K.A., ZEIGLER, K., PETERS, L., and GOFF, F.*
VOLCANIC STRATIGRAPHY OF THE WESTERN SIERRA BLANCA VOLCANIC FIELD, SOUTH-CENTRAL NEW MEXICO

9:00-9:45
Keynote Speaker: G.C. RAWLING, HYDROGEOLOGY OF THE SOUTHERN SACRAMENTO MOUNTAINS

9:45-10:00 Break

Session 3: Hydrogeology of the Sacramento Mountains – Auditorium

Chair: Talon Newton

10:00-10:20 *FINCH, S.T.*
IDENTIFICATION OF A REGIONAL PERCHED GROUNDWATER SYSTEM IN THE SOUTHERN SACRAMENTO MOUNTAINS, OTERO COUNTY, NEW MEXICO

10:20-10:40 *NEWTON, B.T., RAWLING, G., TIMMONS, S., AND KLUDT, T.*
THE STABLE ISOTOPIC COMPOSITIONS OF NATURAL WATERS IN THE SOUTHERN SACRAMENTO MOUNTAINS, NM: IMPLICATIONS FOR CLIMATIC AND HYDROGEOLOGIC CONTROLS ON GROUNDWATER RECHARGE

10:40-11:00 *TIMMONS, S.S., NEWTON, B.T., AND PARTEY, F.K.*
WATER CHEMISTRY TRENDS FROM WELLS AND SPRINGS IN THE SOUTHERN SACRAMENTO MOUNTAINS, NEW MEXICO

Session 2: Spring Microbes and Caves – Galena Room

Chair: Lewis Land

8:15-8:20 WELCOME AND INTRODUCTION

8:20-8:40 *CRON, B., CROSSEY, L., NORTHUP, D.E., KARLSTROM, K.*
MICROBIAL RICHNESS AND DIVERSITY IN CO_2-RICH MOUND SPRINGS OF THE TIERRA AMARILLA ANTICLINE, NEW MEXICO

8:40-9:00 *LAND, L., POLYAK, V., AND NEWTON, T.*
THE SNOWY RIVER FORMATION IN FORT STANTON CAVE, NM: NEW RESULTS FROM RADIOMETRIC DATING AND HYDROLOGIC OBSERVATIONS OF THE WORLD'S LONGEST SPELEOTHEM

9:00-9:45 No talks -- Keynote speaker in main auditorium

9:45-10:00 Break

Session 4: Paleontology – Galena Room

Chair: Spencer Lucas

10:00-10:20 *SPIELMANN, J.A., LUCAS, S.G., KLEIN, H., AND LERNER, A.J.*
VERTEBRATE ICHNOLOGY OF THE UPPER TRIASSIC (APACHEAN) REDONDA FORMATION, EAST-CENTRAL NEW MEXICO

Session 5: Magmatism and volcanism – Galena Room

10:20-10:40 *BRIGHT, R.M., AND AMATO, J.M.*
MESOPROTEROZOIC DIABASE IN SOUTHWESTERN NORTH AMERICA: A PROPOSAL FOR REGIONAL MAGMATISM

10:40-11:00 *GOFF, F., KELLEY, S.A., OSBURN, G.R., LAWRENCE, J.R., GOFF, C.J., FERGUSON, C., McINTOSH, W.C., FELLAH, K., DUNBAR, N.W., AND WOLFF, J.A.*
EVOLUTION OF MOUNT TAYLOR COMPOSITE VOLCANO, NEW MEXICO

11:00-11:20 *NEWTON, B.T., FERNALD, A., GARDUÑO, H., AND KLUDT, T.*
THE SACRAMENTO MOUNTAINS WATERSHED STUDY: PRE-TREATMENT ANALYSES AND CONSIDERATIONS

11:20-11:40 *ZEIGLER, K.E., NEWTON, B.T., and TIMMONS, S.S.*
EFFECTS OF LATERAL AND VERTICAL HETEROGENEITY IN THE YESO FORMATION ON THE REGIONAL HYDROGEOLOGY IN THE SACRAMENTO MOUNTAINS, NM

11:40-12:00 *GARDUÑO, H., FERNALD, A., SHUKLA, M., NEWTON, T., AND VANLEEUWEN, D.*
PLOT-SCALE SOIL WATER FLUX AND RUNOFF IN A MIXED CONIFER FOREST IN THE SACRAMENTO MOUNTAINS, NM**.**

LUNCH (ON OWN)

1:30-2:00 AWARDS CEREMONY – MAIN AUDIOTORIUM

Session 7: Stratigraphy – Main audiotorium

Chair: Shari Kelley

2:00-2:20 *LUCAS, S.G., AND KRAINER, K.*
REVISED PENNSYLVANIAN LITHOSTRATIGRAPHY IN THE MANZANO MOUNTAINS, NEW MEXICO

2:20-2:40 *CONNELL, S.D., SMITH, G.A., GEISSMAN, J.W., MCINTOSH, W.C., DUNBAR, N.W., LOVE, D.W., AND CATHER, S.M.*
^{40}AR/^{39}AR GEOCHRONOLOGY, MAGNETIC-POLARITY STRATIGRAPHY, AND TEPHROCHRONOLOGY OF PLIO-PLEISTOCENE DEPOSITS IN THE ALBUQUERQUE BASIN, RIO GRANDE RIFT, NEW MEXICO

Poster Session in Lobby
2:45-5:00
Snacks and Refreshments

11:00-11:20 *DUNBAR, N.W., KELLEY, S.A., GOFF, F., McINTOSH, W.C., AND HEIZLER, L.L.*
STRATIGRAPHY AND GEOCHEMISTRY OF EARLY PYROCLASTIC ERUPTIONS AT MT. TAYLOR VOLCANO, NEW MEXICO

Session 6: Climate – Galena Room

11:20-11:40 *STURGIS, J. AND GUTZLER, D.S.*
THE INFLUENCE OF ANTECEDENT SNOWPACK, AEROSOLS AND ENSO ON THE NORTH AMERICAN MONSOON

11:40-12:00 *THEILING, B., ELRICK, M., ASMEROM, Y., AND POLYAK, V.*
INSIGHTS INTO THE RELATIONSHIP BETWEEN CONTINENTAL WEATHERING AND HIGH-FREQUENCY (10^4-10^5 YR) GLACIO-EUSTASY FROM CYCLOSTRATIGRAPHY, Δ^{18}O, AND TRENDS IN ε_{ND}

LUNCH (ON OWN)

Session 8: Hydrology – Galena Room

Chair: Kate Zeigler

2:00-2:20 *EL-SADEK, A., BLEIWEISS, M., SHUKLA, M., FERNALD, A., AND GULDAN, S.*
TRANSFERABILITY OF PARAMETERS FOR HYDROLOGIC MODELING OF UNGAUGED WATERSHEDS USING THE SOIL AND WATER ASSESSMENT TOOL

2:20-2:40 *DRAKOS, P., RIESTERER, J., and BEMIS, K.*
INVENTORY OF SPRINGS ON ZUNI TRIBAL LANDS IN WEST-CENTRAL NEW MEXICO: IMPLICATIONS FOR AQUIFER RECHARGE IN THE ZUNI MOUNTAINS AND NORTH PLAINS

Poster Session in Lobby
2:45-5:00
Snacks and Refreshments

Poster Titles and Booth Numbers

Session 1: Paleontology and Stratigraphy

1. *RINEHART, L. F. and LUCAS, S. G.*
A POPULATION OF NONMARINE BIVALVES (UNIONOIDA: ANTHRACOSIIDAE) FROM THE LOWER PERMIAN (WOLFCAMPIAN) SANGRE DE CRISTO FORMATION IN THE ROWE-MORA BASIN, NORTH-CENTRAL NEW MEXICO

2. *McKEIGHEN, K.L., Jr., McKEIGHEN, H.W., LUCAS, S.G., SPIELMAN, J.A., AND HARRIS, S.K.*
EARLY PERMIAN VERTABRATE FOSSILS FROM THE ABO FORMATION AT THE ABO MINE, ABO PASS, NEW MEXICO

3. *McKEIGHEN, H.W., McKEIGHEN, K.L., Jr., LUCAS, S.G., SPIELMANN, J.A., AND HARRIS, S.K.*
DIMETRODON (EUPELYCOSAURIA: SPHENACODONTIDAE) FROM THE UPPER PERMIAN ABO FORMATION, TORRANCE COUNTY, NEW MEXICO

4. *LUCAS, S.G., KRAINER, K., ALLEN, B.D., BARRICK, J.E., VACHARD, D.*
PRECISE AGE OF THE KINNEY BRICK QUARRY LAGERSTÄTTE, PENNSYLVANIAN OF THE MANZANITA MOUNTAINS, NEW MEXICO

5. *LUCAS, S.G., and SPIELMANN, J.A.*
EXCEPTIONALLY-PRESERVED PALEOFLORA FROM THE UPPER TRIASSIC CHINLE GROUP, SANTA FE COUNTY, NEW MEXICO

6. *LUCAS, S.G., KRAINER, K., SPIELMANN, J.A., AND LERNER, A.J.*
THE BURROW *ZOOPHYCOS* IN PENNSYLVANIAN STRATA OF THE MUD SPRINGS MOUNTAINS, SIERRA COUNTY, NEW MEXICO

7. *HUNT-FOSTER, R.K., WILLIAMSON, T.E., AND LONGRICH, N.R.*
ATTEMPTED RELOCATION OF THE 1941 UNIVERSITY OF OKLAHOMA *PENTACERATOPS* QUARRY, SAN JUAN COUNTY, NEW MEXICO

8. *PENCE, R., LUCAS, S.G., WRIGHT, K., AND SPIELMANN, J. A.*
A NEW ASSEMBLAGE OF UPPER CRETACEOUS SELACHIANS: HOSTA TONGUE OF THE POINT LOOKOUT SANDSTONE, BERNALILLO COUNTY, NEW MEXICO

9. *SPIELMANN, J.A., RINEHART, L.F., LUCAS, S.G., BERMAN, D.S., HENRICI, A.C., AND HARRIS, S.K.*
CRANIAL ANATOMY AND TAXONOMY OF *SPHENACODON FEROX* (EUPELYCOSAURIA: SPHENACODONTIDAE) FROM THE LATE PENNSYLVANIAN-EARLY PERMIAN OF NEW MEXICO

10. *SULLIVAN, R.M., BRAMAN, D.R., JASINSKI, S.E., LUCAS, S.G.*
NEW PALYNOLOGICAL DATA FROM CRETACEOUS STRATA IN THE SAN JUAN BASIN, NEW MEXICO, DO NOT INDICATE A PALEOCENE AGE FOR DINOSAUR FOSSILS

11. *SEALEY, P.L., AND LUCAS, S.G.*
UPPER CRETACEOUS (TURONIAN) AMMONITES FROM THE CARLILE AND JUANA LOPEZ MEMBERS OF THE MANCOS SHALE, EASTERN SIDE OF MESA PRIETA, SANDOVAL COUNTY, NEW MEXICO

12. *WRIGHT, K., BOURDON, J., LUCAS, S., AND PENCE, R.*
NEW MEXICO'S MOST PROLIFIC UPPER CRETACEOUS SHARK ASSEMBLAGE: HOSTA TONGUE OF THE POINT LOOKOUT SANDSTONE, BERNALILLO COUNTY, NEW MEXICO

13. *HARRIS, S.K., LUCAS, S.G., AND SPIELMANN, J.A.*
THE MOST COMPLETE SKELETON OF *OPHIACODON NAVAJOVICUS* (EUPELYCOSAURIA: OPHIACODONTIDAE), FROM THE UPPER PENNSYLVANIAN OF CAÑON DEL COBRE, NEW MEXICO

14. *KRAINER, K., LUCAS, S.G., SPIELMANN, J.A., AND DURNEY, K.*
CRETACEOUS DEPOSITIONAL ENVIRONMENTS AND SEQUENCE STRATIGRAPHY AT CERRO DE CRISTO REY, DOÑA ANA COUNTY, NEW MEXICO

15. *LERNER, A.J., LUCAS, S.G., AND MacDONALD, J.P.*
ADDITIONAL INVERTEBRATE ICHNOTAXA FROM THE LOWER PERMIAN HUECO GROUP, ROBLEDO MOUNTAINS, SOUTH-CENTRAL NEW MEXICO

Session 2: Granite and rock piles

16. *PITRUCHA, R.M., AND LINDLINE, J.*
PETROLOGIC CHARACTERISTICS OF GRANITIC PHASES WITHIN THE HERMIT'S PEAK BATHOLITH

17. *WILLIAMS, S.F.*
MODELING PYRITE AND FLUORIDE CONCENTRATION IN THE GOATHILL NORTH ROCK PILE, QUESTA MINE, NEW MEXICO

Session 3: Hydrogeology

18. *REYES, F., ADELBERG, S., WILLIAMS, A., CROSSEY, L.J., AND KARLSTROM, K.E.* A SALINIZATION STUDY WITHIN THE SAN ACACIA REGION, SEVILLETA NATIONAL WILDLIFE REFUGE (SNWR), NEW MEXICO

19. *LAND, L., RAWLING, G., AND TIMMONS, S.*
A REGIONAL WATER TABLE MAP AND WATER LEVEL VARIATIONS IN THE SOUTHERN SACRAMENTO MOUNTAINS WATERSHED, NEW MEXICO

Session 4: Geophysics and structure

20. *PETRONIS, M.S., AND LINDLINE, J.*
PALEOMAGNETIC DATA FROM LATE MIOCENE LOBATO BASALT FLOWS ADJACENT TO THE SANTA CLARA FAULT SYSTEM, CHILI QUADRANGLE, RIO ARRIBA COUNTY, NEW MEXICO

21. *ASHU, R.A., AND PETRONIS, M.S.*
GEOPHYSICAL DATA BEARING ON HYDROCARBON TRAPS AND RESOURCE POTENTIAL OF THE GALISTEO BASIN, NEW MEXICO

22. *AVANT, T.B., AND AMATO, J.M.*
ORIGIN AND TIMING OF FOLDING WITHIN THE LINCOLN FOLD BELT, LINCOLN COUNTY, NEW MEXICO

Session 5: Alluvial fans and travertine deposits

23. *FAULCONER, J., AND MEYER, G.A.*
CONTROLS ON PARTICLE-SIZE DISTRIBUTIONS IN TRIBUTARY ALLUVIAL FANS OF THE LOWER CHAMA RIVER CANYON

24. *PRIEWISCH, A., CROSSEY, L.J., EMBID, E., and KARLSTROM, K.E.*
GEOCHRONOLOGY, GEOCHEMISTRY AND TECTONIC OCCURRENCE OF TRAVERTINE DEPOSITS IN NEW MEXICO AND ARIZONA

Session 6: Geologic mapping and spatial archeology

25. *LOVE, D.W., ALLEN, B.D., and MYERS, R.G.*
PRELIMINARY GEOLOGIC MAP OF THE CAPITOL PEAK SE QUADRANGLE WITH ILLUSTRATIONS OF UNCOMMON SURFICIAL FEATURES, NORTHERN TULAROSA BASIN, SOUTH CENTRAL NEW MEXICO

26. *McCRAW, D. J.*
GEOLOGIC COMPILATION MAP OF THE LOWER PECOS ALLUVIAL VALLEY, BITTER LAKE TO BOTTOMLESS LAKES AREA, CHAVES COUNTY, NEW MEXICO

27. *RAWLING, G.C.*
GEOLOGIC MAP OF THE SOUTHERN SACRAMENTO MOUNTAINS, OTERO AND CHAVEZ COUNTIES, NEW MEXICO

28. *ZEIGLER, K.E., HUGHES, C., KUROTA, A., AND HOGAN, P.*
NATIVE AMERICAN LITHIC PROCUREMENT PATTERNS AND SITES IN THE BOOT HEEL OF SOUTHWESTERN NEW MEXICO

GEOPHYSICAL DATA BEARING ON HYDROCARBON TRAPS AND RESOURCE POTENTIAL OF THE GALISTEO BASIN, NEW MEXICO, *ASHU*, *R.A.*,

aragbor@yahoo.com, and *PETRONIS*, *M.S.*, Environmental Geology, Natural Resource Management Department, New Mexico Highlands University, Las Vegas, New Mexico 87701

Land-based Gravity and Magnetic data were obtained at 56 gravity and 250 magnetic stations throughout the northern to central Galisteo Basin south of Santa Fe, NM. The study area extends south from the village of Eldorado to the foothills of the Ortiz Mountains and east from I-25 to Highway 285; an area of approximately 3600 km^2. These data provide a novel approach in subsurface investigations by integrating surface geological mapping and subsurface geophysical surveys to characterize the geometry, distribution, depth, and potential hydrocarbon trap geometries in parts of the Galisteo Basin in 2.5D using the *Talwani* and *GravMag* geophysical modeling softwares and field exploration methods. The structurally complex nature of the Galisteo Basin provides an excellent location for stratigraphic and structural trap exploration using geophysical methods due to the density and susceptibility contrasts between the various Formations within the basin. Gravity and magnetic data were modeled along several regional profiles on selected parts of the Galisteo Basin, combined with surface geologic information, to constrain the nature of the subsurface. Both sets of potential field data were integrated into *ArcGIS 9.3* and *Surfer* 8.0 to generate extrapolated surfaces and derivative maps which allowed for the characterization of the subsurface geology along specific profiles across the mapped area. These data reveal that several anomalies exist within the central portion of the basin which we interpret as likely hydrocarbon trap-structures. In order to investigate the possible geometries of the anomalies, detailed forward models are being developed to assess possible trap structures, extent, and distribution within the basin. These data should allow us to estimate the hydrocarbon potential within select parts of the basin and provide an estimate of reserves present.

ORIGIN AND TIMING OF FOLDING WITHIN THE LINCOLN FOLD BELT, LINCOLN COUNTY, NEW MEXICO, *AVANT*, *T.B.*, and *AMATO*, *J.M.*, Department of Geological Sciences, New Mexico State University, Las Cruces, New Mexico 88003

The Lincoln Fold Belt contains a set of disharmonic, short wavelength folds with a controversial timing and origin. Located just outside the village of Lincoln, New Mexico, folded sedimentary rocks of the Leonardian (Middle Permian) Yeso Formation are exposed in the surrounding hills. The overlying Permian San Andres formation is poorly exposed and contains harmonic folds with long wavelengths. Both of these units are located in an area with a complex geologic history.

Previous stratigraphic and structural studies resulted in several possible mechanisms and ages of fold formation being proposed. Estimates of the age of fold formation range from Permian (syndepositional) to Tertiary. Proposed mechanisms for the formation of the folds include soft-sediment deformation, gravitational mass wasting and slumping, Laramide deformation, deformation caused by the dikes and sills from either the nearby Capitan Pluton or the Sierra Blanca intrusion, and deformation caused by movement along basement faults.

Mapping of the study area has yielded bedding measurements within the Yeso Formation that strike predominantly northwest/southeast, and fold axes that trend predominantly northeast/southwest. Wavelength measurements in the Yeso folds range from 10-60 m. Fold trends do not vary significantly with distance measured perpendicular to the fold axes. Bedding within the overlying San Andres does not appear to have a consistent strike pattern, but all fold axis measurements trend north to northeast. Wavelengths in San Andres folds range from 300-400 m. The Yeso-San Andres contact is discordant, possibly due to the presence of an unconformity or fault. U-Pb dating of cross-cutting diabase dikes will be used to better constrain the timing of folding.

MESOPROTEROZOIC DIABASE IN SOUTHWESTERN NORTH AMERICA: A PROPOSAL FOR REGIONAL MAGMATISM, *BRIGHT*, *R.M.*, lithological@gmail.com, and *AMATO*, *J.M.*, Department of Geological Sciences, New Mexico State University, MSC 3AB, P.O. Box 30001, Las Cruces, New Mexico 8003-8001

Timing and petrogenesis of a Mesoproterozoic mafic dike swarm in southwestern North America is poorly understood. Existing diabase ages range from 1200 Ma-1080 Ma, but most have poor precision. Diabase samples collected from the Organ and Burro Mountains of southern New Mexico and from the Salt River Canyon, Sierra Ancha, Pinaleno, Santa Catalina, Hualapai, and Garnet Mountains of eastern and northwestern Arizona intrude Proterozoic sediments and granites in the form of dikes and sills. Diabases are typically medium grained with ophitic and subophitic texture and have plagioclase laths, near ~1 mm in length. Subhedral olivine crystals are present in most New Mexico and SE Arizona diabase, but they are uncommon in NW Arizona diabase. Feldspar compositions for the Burro and Sierra Ancha Mtns. range from An .321 to An 70.43. Pyroxene compositions of the Burro and Sierra Ancha Mtns. reflect the presence of both clinopyroxene (augite) and orthopyroxene (hypersthene), and pigeonite. Strontium isotope analyses of Burro Mtns. diabase show $^{87}Sr/^{86}Sr$ ratios ranging from 0.700624-0.705408 for single plagioclase crystals, which spans higher than whole rock values ranging from 0.702076-0.703484 indicating likely assimilation of the host granite by the dikes. We obtained a U-Pb zircon age of 1115±13 Ma (2s) using LA-MC-ICP-MS on a dike from Salt River Canyon in Arizona. This age is older than U-Pb baddeleyite ages of 1087±3 Ma and 1069±3 Ma obtained from two diabase sills in California (Heaman and Grotzinger, 1992). This discrepancy suggests there are two different aged dike swarms or there was a long lived magmatic interval. Dikes with ages closer to 1100 Ma may be related to the Midcontinent Rift (Hammond, 1990).

^{40}AR/^{39}AR GEOCHRONOLOGY, MAGNETIC-POLARITY STRATIGRAPHY, AND TEPHROCHRONOLOGY OF PLIO-PLEISTOCENE DEPOSITS IN THE ALBUQUERQUE BASIN, RIO GRANDE RIFT, NEW MEXICO, *CONNELL, S.D.,* connell@gis.nmt.edu, New Mexico Bureau of Geology and Mineral Resources-Albuquerque Office, New Mexico Institute of Mining and Technology, 2808 Central Ave., SE, Albuquerque, New Mexico 87106; *SMITH, G.A., and GEISSMAN, J.W.,* Department of Earth and Planetary Sciences, MSC03 2040, University of New Mexico, Albuquerque, New Mexico 87131*; McINTOSH, W.C., DUNBAR, N.W., LOVE, D.W., and CATHER, S.M.*, New Mexico Bureau of Geology and Mineral Resources, New Mexico Institute of Mining and Technology, 801 Leroy Place, Socorro, New Mexico 87801

The geochronology of alluvial deposits in the Albuquerque Basin are refined using 20 previously published and 58 new (single-crystal laser-fusion and incremental heating) ^{40}Ar/^{39}Ar age determinations and tephrochronologic correlations of (primary and reworked) tephra and lavas younger than 10 Ma. These data provide a robust geochronologic framework that was used to develop a reversal magnetic-polarity stratigraphy for Plio-Pleistocene fluviatile sandstone, conglomerate, and mudstone of the Ceja and Sierra Ladrones Formations (upper Santa Fe Group). Tilt-corrected means of all class I (highest quality) sites (normal polarity: D = 2.8º, I = 45.0º, n = 58; reverse polarity: D = 180.2º, I = -41.7º, n = 50) document nearly all polarity changes (longer than 20 ka) since 4.0 Ma and are suitable for correlation to the global polarity timescale. The Ceja Fm onlapped the late Miocene (*ca.* 6.3 Ma) Rincones paleosurface, and buried it by about 3.0 Ma. After 3.0-2.6 Ma, the Ceja Fm became considerably coarser-grained and carried scattered small boulders. Ceja deposition ended shortly after the Olduvai subchron (1.778 Ma) with the formation of a relict depositional surface (Llano de Albuquerque surface). Axial-fluvial deposits of the Sierra Ladrones Fm (ancestral Rio Grande) had entered the northern part of the basin by late Miocene time (*ca.* 7 Ma), and through-going axial-river drainage was established into southern New Mexico by early Pliocene time (*ca.* 4.8 Ma). The axial river once flowed 1-5 km west of the eastern basin-bounding fault system before migrating to the present position of the Rio Grande Valley after 1.8-1.6 Ma. Deposition of the Sierra Ladrones Fm ceased shortly after the beginning of the Brunhes polarity chron (0.781 Ma), and before deposition of the oldest known inset fluvial terrace deposit in the Rio Grande Valley near Albuquerque, which contains the 0.64 Ma Lava Creek B ash. Valley incision abandoned an early Pleistocene basin-floor and flanking piedmont-slopes of the Sunport, Las Huertas, and Llano de Manzano surfaces. Incision of the Rio Grande in central and southern New Mexico began before the 0.45 Ma age of breaching of Lake Alamosa (San Luis Basin) in the headwaters region of Colorado and may not be a direct result of drainage capture in the upper Rio Grande.

MICROBIAL RICHNESS AND DIVERSITY IN CO_2-RICH MOUND SPRINGS OF THE TIERRA AMARILLA ANTICLINE, NEW MEXICO, *CRON*, *B.,* b1985@unm.edu, and *CROSSEY*, *L.,* Department of Earth and Planetary Sciences, University of New Mexico, Albuquerque, New Mexico 87131; *NORTHUP*, *D.E.,* Department of Biology, University of New Mexico, Albuquerque, New Mexico 87131; and *KARLSTROM*, *K.,* Department of Earth and Planetary Sciences, University of New Mexico, Albuquerque, New Mexico 87131

A series of mesothermal (~25 ^oC) mound springs located along the Tierra Amarilla (TA) anticline are related to a regional occurrence of CO_2-rich travertine depositing springs in north-central New Mexico. Previous work has shown that these springs exhibit geochemical ($^3He/^4He$ and $CO_2/^3He$) evidence for the presence of endogenic fluids. We have hypothesized that CO_2-rich mound springs such as TA exhibit tectonic, geochemical, and microbiological similarities to marine vent systems. To assess the geochemistry and the metabolic reactions in these springs on a real-time basis, we deployed multi-parameter sondes at various depths in two springs on the axis of the anticline. Continuous measurements of pH, temperature, conductivity, dissolved oxygen, and depth were collected every five minutes for five days. The temperature and pH results indicate a weak diurnal signal at ~1 meter depth at the higher-discharge spring. The data from ~6 meter depth from the same spring displayed invariant temperature at ~26^oC, pH 6, and anaerobic conditions. We use established protocols from studies for geochemical modeling to assess energetics in extreme environments. We use denaturing gradient gel electrophoresis (DGGE) to determine whether the mesothermal springs have similar species composition to hydrothermal vents. Environmental samples were collected on 0.22 micrometer Millipore Sterivex filters from several springs and preserved in sucrose lysis buffer. DGGE bands were sequenced from mud and filtered DNA extracts. These samples were found to be significantly similar to marine organisms (>94%). DNA was found to be 94% similar to *Zetaproteobacteria* that are also found in the deep-sea hydrothermal region of the East Lau Spreading Center and uncultured environmental bacterial samples collected from seamounts located along the Kermadec Arc (96% similarity). *Algoriphagus* sp. LYX05, an organism isolated from sediment along the coastal region of the Yellow Sea, was the closest relative to clones obtained from another spring (97% similarity). These data support the hypothesis that CO_2-rich springs in terrestrial extensional settings have similarities to marine vents and offer rich potential for linking mantle fluids to near-surface hydrochemistry and unique microbial niches.

INVENTORY OF SPRINGS ON ZUNI TRIBAL LANDS IN WEST-CENTRAL NEW MEXICO: IMPLICATIONS FOR AQUIFER RECHARGE IN THE ZUNI MOUNTAINS AND NORTH PLAINS, *DRAKOS*, *P.,* drakos@glorietageo.com, and *RIESTERER*, *J.,* Glorieta Geoscience, Inc., PO Box 5727, Santa Fe, New Mexico 87501; and *BEMIS*, *K.,* Zuni Conservation Program, PO Box 339, Zuni, New Mexico 87327

An inventory of 29 springs on the Zuni Reservation conducted between 2007 and 2009 focused on four areas: Nutria, Pescado, Dowa Yalanne-Black Rock, and Ojo Caliente (northeast, east-central, central, and southwest regions of the reservation, respectively). Springs discharge from the Permian San Andres-Glorieta (Psg), Triassic Chinle, Triassic-Jurassic Wingate-Zuni, and interconnected Quaternary alluvium/fractured basalt (Qal/Qb) aquifers. Spring assessments included geologic mapping, measurement of discharge and field water quality parameters, spring classification, and geochemical analyses.

Relatively high-volume springs (100-300 gpm) discharge from the Psg and Qal/Qb aquifers. Psg springs in the Nutria area, near the recharge source in the Zuni Mountains, exhibit a mixture of modern (<5-10 year old) and pre-1952 recharge, indicating spring discharge from shallow and deep circulation systems near the mountain front. Ojo Caliente Psg springs are fenn-type springs that represent predominantly or entirely pre-1952 recharge. Stable isotope ($\delta^{18}O$ and $\delta^{2}H$) data are consistent with high elevation, winter precipitation recharge for Nutria area Psg springs and a lower elevation North Plains/Continental Divide recharge source southeast of the reservation for the Ojo Caliente springs. Alluvial springs in the Black Rock area exhibit modern recharge, whereas discharge from Pescado area alluvial springs represents predominantly pre-1952 recharge. These data indicate that Pescado area springs discharge from a deeper (possibly leaky-confined) alluvial/fractured basalt flow system, whereas Black Rock alluvial springs discharge from a shallow, unconfined alluvial flow system. Springs discharging from the Chinle and Zuni/Wingate aquifers exhibit variable recharge, with some receiving rapid recharge from winter precipitation and others showing older recharge from summer monsoons.

Spring discharge measurements conducted during this investigation, when compared to earlier studies conducted by Orr (1987) and Summers (1972), suggest a generally declining trend in spring flows between 1972 and 2009. This apparent trend is supported by Zuni research which identified several historically productive, although low-discharge, springs that were dry during 2007-2009 site visits.

STRATIGRAPHY AND GEOCHEMISTRY OF EARLY PYROCLASTIC ERUPTIONS AT MOUNT TAYLOR VOLCANO, NEW MEXICO, *DUNBAR*, *N.W.,* nelia@nmt.edu, and *KELLEY*, *S.A.,* New Mexico Bureau of Geology and Mineral Resources, New Mexico Institute of Mining and Technology, Socorro, New Mexico, 87801; *GOFF*, *F.,* Department of Earth & Planetary Sciences, University of New Mexico, Albuquerque, New Mexico 87131; *McINTOSH*, *W.C.,* and *HEIZLER*, *L.L.,* New Mexico Bureau of Geology and Mineral Resources, New Mexico Institute of Mining and Technology, Socorro, New Mexico 87801

Rhyolitic to trachyandesitic pyroclastic deposits exposed in three canyons (La Mosca, San Mateo, and Water) around the Mt. Taylor edifice provide insight into early eruption processes at this composite volcano. Measured sections coupled with geochemical analysis of glass allow correlations between the canyon sections and, for some deposits, sources areas to be determined. A 4 m thick pyroclastic surge and ashfall deposit at the base of the La Mosca Canyon section, dated at 3.26±0.04 Ma, correlates chemically and chronologically with 3.3 Ma Grants Ridge high silica rhyolitic deposits sourced 15 km southwest of Mt. Taylor. Overlying this deposit is a 1 m. thick rhyolitic pyroclastic surge. Both deposits are absent in the nearby San Mateo Canyon, where instead, a >28 m thick, complex sequence of rhyolite ignimbrites and pyroclastic surges is found at the base of the exposed stratigraphic section. An ignimbrite in Water Canyon is chemically similar to the upper part of the basal San Mateo pyroclastic sequence. Above these pyroclastic surge and flow deposits in San Mateo Canyon, a series of small, chemically correlated, pyroclastic fall deposits are found in San Mateo and La Mosca canyons. Two rhyolitic ashfalls (one dated to 3.08±0.2 Ma), and a thin, dark-colored trachyandesite fall deposit are present. The upper of the two rhyolitic ashfalls is also found in Water Canyon. Above this sequence of ashfalls, a thick (~22 m.) rhyolitic pyroclastic flow sequence is present in San Mateo canyon that chemically correlates with a thin (<1 m.) pyroclastic fall in La Mosca canyon. All these pyroclastic beds are probably sourced from sites within Mt. Taylor.

The chemical trend of the pyroclastic sequences in the canyons ranges from high silica to low silica rhyolite, consistent with derivation from a single, normally zoned magma chamber. However, the presence of the trachyandesitic tephra layer in the middle of the sequence may argue instead for multiple, small magma batches. Individual pyroclastic flow/surge deposits appear to have restricted ranges, consistent with small volume, high aspect ratio events, possibly related to dome collapse in early Mt. Taylor. In contrast, pyroclastic fall deposits, although small, are more widespread, and are deposited in all three canyons, allowing correlation between the stratigraphic sections.

TRANSFERABILITY OF PARAMETERS FOR HYDROLOGIC MODELING OF UNGAUGED WATERSHEDS USING THE SOIL AND WATER ASSESSMENT TOOL,
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A common problem in applied hydrology is the estimation of hydrological behavior of ungauged watersheds. One approach to this problem is to use comparative hydrology, which seeks to transfer hydrological information from a gauged site to the ungauged site. The main objective of this study is to implement this strategy on watersheds in New Mexico using model calibration and validation to solve the problem of the lack of stream flow records. This is being accomplished using the physically-based, distributed, Soil and Water Assessment Tool (SWAT). Our approach is to use gauged watersheds as surrogates for ungauged watersheds so that our results can be verified. The two ways in which hydrologic information can be transferred within or between watesheds are via a spatial or a temporal transformation. We have accomplished the temporal transformation of parameters in the Mimbres Basin of southwest New Mexico during the period from 2002 to 2008 using several different scenarios: transfer parameters from the period 2002-2005 to 2005-2008, from 2005-2008 to 2002-2005, and from 2003-2006 to 2005-2008. These three scenarios resulted in Nash-Sutcliffe Efficiencies (NSE) of 0.40, 0.44, and 0.43, respectively. The spatial transfer within a watershed has already been conducted; i.e., a NSE was 0.64 when transferring parameters from Embudo Creek to Rio Pueblo near Penasco and it was -0.22 when parameters were transferred from Rio Pueblo near Penasco to Embudo Creek (Embudo Creek contains the Rio Pueblo in its upper reaches). In addition to the temporal and within watershed transformation of parameters, we are also performing a spatial transformation among 5 watersheds in northern New Mexico: Vermejo River near Dawson, Cimarron River near Cimarron, Rio de Taos below Los Cordovas, Embudo Creek at Dixon and the Jemez River near Jemez. The details of this work and the results of the spatial transformation will be discussed.

CONTROLS ON PARTICLE-SIZE DISTRIBUTIONS IN TRIBUTARY ALLUVIAL FANS OF THE LOWER CHAMA RIVER CANYON, *FAULCONER*, *J.,* jfaulcon@unm.edu, and *MEYER*, *G.A.,* Department of Earth & Planetary Sciences, Northrop Hall, University of New Mexico, Albuquerque, New Mexico 87131

Tributary alluvial fans in the lower Chama River Canyon, in northern New Mexico between Christ in the Desert Monastery and Big Eddy boat ramp north of Abiquiu Reservoir, affect the main channel form and slope of the Chama River in various ways. Some fans deposit bouldery debris flows into the river, creating rapids. Other fans deposit large volumes of sandy sediment, in some cases pushing the river to the opposite side of the valley. The purpose of this study is to determine the controls on alluvial fan size, morphology, and sediment texture that result in these differences.

Most tributaries have cut channels into their fans, creating exposures of the fan stratigraphy. Sample sites along the length of each tributary channel were used to determine particle size distribution, from which the median particle size, sorting, and other measures where derived. In the field, the fan boundaries and channel boundaries were mapped. Digital elevation models (DEMs) were used in ArcGIS to delineate the drainage basins for each fan, the area, relief, and slope angles of the drainage basins, and the area and slope of the fans. ArcGIS was also used to determine each geologic units' role on particle size and distribution on fan; in the study area the geologic units include Triassic Chinle Group through Cretaceous Dakota Formation sedimentary rocks.

Drainage basin area, stream length, and stream magnitude have a significant impact on particle size on fan. Larger area, longer length, and higher magnitude produce larger mean particle sizes on fans. The ratio between fan size and drainage basin size also appears important. Smaller fans tend to have less fining of clast size down fan, especially if their drainage basin is large in comparison with fan area. These fans produce bouldery debris flows into the river. Large fans, especially if their drainage basin is relatively small, have more down fan fining of particle size. In some cases these fans redirect the river channel with large volumes of sandy sediment.

Bedrock geology appears to have a strong influence on the fan's particle size, where a greater percent area of Dakota Fm produces abundant boulders and a larger mean particle size. Morrison Fm and Entrada sandstones tend to weather by granular disintegration, and along with Petrified Forest Fm mudstones, produce overall smaller particle sizes.

IDENTIFICATION OF A REGIONAL PERCHED GROUNDWATER SYSTEM IN THE SOUTHERN SACRAMENTO MOUNTAINS, OTERO COUNTY, NEW MEXICO,

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The southern Sacramento Mountains, defined in this study as the mountains south of U.S. 70 to Otero Mesa, are dominated by a 40-mile long, north-south trending crest with an average elevation of 8,000 ft amsl. The Sacramento Mountain crest is capped with Permian-age sediments of the San Andres Limestone and Yeso Formation, and these sedimentary rocks slope gradually to the east toward the Pecos River about 80 miles away. Water resources of the Sacramento Mountains have been studied extensively over the past several decades, particularly in the developed areas of Ruidoso, Cloudcroft, and Timberon, New Mexico. Two common themes have emerged from these studies: 1) most springs in the Sacramento Mountains occur at the San Andres-Yeso contact, and 2) the San Andres Limestone and Yeso Formation are considered as a regional aquifer hydraulically connected.

Results from deep well drilling at Cloudcroft demonstrate the primary groundwater system is perched in the San Andres Limestone and underlying limestone beds in the Upper Yeso Formation. Near the crest, the strata underlying this regional perched groundwater system is largely unsaturated with localized pockets of saline groundwater. The lateral extent of this regional perched groundwater system has been defined by groundwater-elevation and water-chemistry data. Farther east of the crest and down slope, the strata underlying the regional perched groundwater system contains a regional groundwater system approximately 200 ft lower in elevation and characterized by older water with chemistry different than the perched system. The regional perched groundwater system in the southern Sacramento Mountains covers approximately 300 square miles from Cloudcroft to Timberon, and is defined by groundwater-elevation contours greater than 6,600 ft amsl. This perched groundwater system is the primary source for springs and perennial streams in the southern Sacramento Mountains, and recharge to the Pecos Slope.

PLOT-SCALE SOIL WATER FLUX AND RUNOFF IN A MIXED CONIFER FOREST IN THE SACRAMENTO MOUNTAINS, N.M., *GARDUÑO, H.,* and *FERNALD, A.,* Animal and Range Sciences Department. New Mexico State University; *SHUKLA, M.,* Plant and Environmental Sciences Department, New Mexico State University, Las Cruces 88003; *NEWTON, T.,* New Mexico Bureau of Geology and Mineral Resources, New Mexico Institute of Mining and Technology, 801 Leroy Place, Socorro, New Mexico 87801; and *VANLEEUWEN, D.,* Department of Economics and International Business, New Mexico State University, Las Cruces, New Mexico 88003

Mechanical thinning effects in forested stands have been widely studied, yet at the plot-scale, thinning effects on runoff, soil water flux, and water balance are scarcely reported. The objectives of this study were to identify runoff zones and to calculate soil water fluxes prior to mechanical thinning of mixed conifer stands. The study was carried out on private property near James Canyon approximately 20 km east of Cloudcroft, NM. The study site is underlain by San Andres and Yeso formation mainly composed of Douglas Fir (*Pseudotsuga menziesii*) and Ponderosa Pine (*Pinus ponderosa*) with a tree density average of 770 trees ha^{-1}. Soil type is Typic Argiborolls-Aquic Haploborolls with loam and clay loam soil textures. Two plots (90 x 90 m each) were selected at each of 4 locations characterized by combinations of site (hilltop, slope bottom) and aspect (North-facing, South-facing). Runoff evaluation prior to mechanical treatment was carried out in late June and early July in 2009. A total of 24 rainfall simulations (3 simulations per plot) were done with soil at field capacity. Sixty-min simulated rainfall was applied to each $1m^2$ plot to determine runoff and sediment yield. Infiltration was determined as the difference between simulated rainfall and runoff. A set of three soil moisture and heat dissipation sensors were installed on each plot at 0.07, 0.20, and 0.35 m depth. Soil water flux was calculated by Darcy's equation. Total potential head was calculated from gravitational and the matric potential measured from heat dissipation sensors using Retention Curve (RETC) software. The gradient-causing flow was calculated from the sum of gravitational potential and matric potential from sensors previously mentioned. Results showed that runoff and sediment yield were negligible likely due to high infiltration rate and limestone bedrock. Runoff as a percentage of total water input was 0.004 % at the hilltop and 0.02 % at the slope bottom. At the hilltop, water flux was 9.34 e^{-04}- 2.15 e^{-04} m h^{-1} and at the slope bottom water flux was 6.64 e^{-04}- 2.21 e^{-04} m h^{-1}. Overall water flux was higher at 7 cm (4.28 e^{-04} m h^{-1}) and 20 cm depth (4.21 e^{-04} m h^{-1}) than at 35 cm depth (5.21 e^{-04} m h^{-1}). Regardless of site and aspect, infiltration responded rapidly to simulated rainfall where possibilities of deep percolation are greater due to fracture limestone. Though preliminary results, this study helped to improve our understanding of the shallow root zone water interactions in forested stands. Data collected from this study will help to determine thinning effects at plot scale on soil water flux, runoff, and water balance.

EVOLUTION OF MOUNT TAYLOR COMPOSITE VOLCANO, NEW MEXICO, *GOFF*, *F.,* candf@swcp.com, Department of Earth & Planetary Sciences, University of New Mexico, Albuquerque, New Mexico 87131; *KELLEY*, *S.A.*, New Mexico Bureau of Geology & Mineral Resources, New Mexico Institute of Mining and Technology, 801 Leroy Place, Socorro, New Mexico 87801; *OSBURN*, *G.R.*, Earth & Planetary Sciences, Washington University, St. Louis, Missouri 63130; *LAWRENCE*, *J.R.*, Lawrence GeoServices Ltd. Co., 2321 Elizabeth St. NE, Albuquerque, New Mexico 87112; *GOFF, C.J.,* Geologic Consultant, 5515 Quemazon, Los Alamos, New Mexico 87544; *FERGUSON*, *C.*, Professional Geologist, 119 North Fork Rd., Centennial, Wyoming 82055; *McINTOSH*, *W.C.*, New Mexico Bureau of Geology & Mineral Resources, New Mexico Institute of Mining and Technology, 801 Leroy Place, Socorro, New Mexico 87801; *FELLAH*, *K.*, School of Earth and Environmental Sciences, Washington State University, Pullman, Washington 99164; *DUNBAR*, *N.W.*, New Mexico Bureau of Geology & Mineral Resources, New Mexico Institute of Mining and Technology, 801 Leroy Place, Socorro, New Mexico 87801; and *WOLFF*, *J.A.*, School of Earth and Environmental Sciences, Washington State University, Pullman, Washington 99164

Detailed mapping of four 1:24,000 quadrangles augmented with >40 $^{40}Ar/^{39}Ar$ dates, >100 major and trace element analyses, and previously published data provide new insights on the evolution of Plio-Pleistocene Mount Taylor (MT) composite volcano. MT is one of a string of Miocene–Quaternary volcanoes erupted along the NE-trending Jemez lineament and overlies Jurassic–Cretaceous sedimentary rocks of the Colorado Plateau. The 20-km3 edifice is constructed of mildly alkaline volcanic rocks of basanite to alkali rhyolite composition. Most mafic rocks contain phenocrysts of olivine and plagioclase whereas intermediate to silicic rocks contain phenocrysts of plagioclase, hornblende and/or biotite. Rare trachybasalts contain phlogopite. Trachydacites and rhyolites may contain alkali feldspar and quartz. Virtually all volcanics contain clinopyroxene.

Volcanism began with eruption of basanite lavas (3.6 Ma) and a distinctive fine-grained trachyte (3.3 Ma) followed by multiple eruptions of alkali rhyolite to trachyandesite lavas, domes and pyroclastic deposits (3.1–2.8 Ma). During the first period, a heretofore unrecognized sequence, up to 110 m thick, of rhyolitic fall, flow and surge deposits interlayered with volcanic sediments was emplaced beneath the NW volcano flank. The early phase culminated with widespread eruption of coarse-grained, plagioclase-phyric, trachybasalt to basaltic trachyandesite flows (2.86–2.76 Ma, n = 3). The final phase (2.8–2.5 Ma) produced intermingled trachyandesite to trachydacite domes, flows and minor pyroclastic beds cut by a radial swarm of trachydacite dikes. These units are intruded by a small composite stock of trachydacite to alkali rhyolite. As the final phase developed, volcanic debris flows accumulated on the volcano flanks.

More than 60 porphyritic to aphyric trachybasalt lavas and scoria cone deposits (3.3–<1.7 Ma) are interlayered with MT eruptions and flank MT on Horace Mesa, Mesa La Jara, and southern Mesa Chivato. Contemporaneous gabbroic intrusions of similar composition (3.1–<2.8 Ma) created San Fidel Dome and other small uplifts. Debris flows and tuffs deposited on mesas adjacent to MT define a possible hiatus in mafic activity that occurred 2.7–2.2 Ma. The youngest trachybasalt complex (Cerro Pelón) is about 1.5 Ma and sits on the north shoulder of MT.

THE MOST COMPLETE SKELETON OF *OPHIACODON NAVAJOVICUS* (EUPELYCOSAURIA: OPHIACODONTIDAE), FROM THE UPPER PENNSYLVANIAN OF CAÑON DEL COBRE, NEW MEXICO, *HARRIS*, *S.K., LUCAS*, *S.G.,* and *SPIELMANN*, *J.A.,* New Mexico Museum of Natural History and Science, 1801 Mountain Road NW, Albuquerque, New Mexico 87104

The most complete postcranial skeleton known of the Late Pennsylvanian pelycosaurian-grade synapsid *Ophiacodon navajovicus* is from the Upper Pennsylvanian interval of the El Cobre Canyon Formation (Cutler Group) at Cañon del Cobre, Rio Arriba County, New Mexico. The skeleton was preserved in brownish-red mudstone with blue concretions located approximately 80 m below the contact of the El Cobre Canyon Formation and the overlying Arroyo del Agua Formation. Cranial elements are represented by fragments of the right maxilla and dentary. The postcranial elements include vertebrae representative of all regions of the vertebral column, a nearly complete pelvis, a complete right femur and portions of other limb bones, as well as bones of the right pes. The completeness of the skeleton contrasts with most other collections of *O. navajovicus*, which consist of isolated elements. *O. navajovicus* differs from all other known species of *Ophiacodon* in the retention of the following primitive characters: ventral ridge of the postaxial presacral centra are flat with well-defined longitudinal borders, adductor ridge of the femur is weakly developed and positioned mid-ventrally along the shaft, and the neck of the astragalus is almost half of the proximodistal length of the element. The unique morphology of the ventral surface of the centrum in *O. navajovicus* is potentially advantageous in the identification of isolated thoracic centra when present in combination with the typical ophiacodontid wing-shaped transverse process, in which a web of bone extends from the diapophyses to the parapophysis and the centrum has a wedge-shaped cross-sectional outline. Therefore, *O. navajovicus* can be considered of potential use in Late Pennsylvanian tetrapod biostratigraphy. As currently understood, the stratigraphic distribution of *O. navajovicus* in New Mexico, Utah and Colorado indicate that *O. navajovicus* characterizes the Cobrean land-vertebrate faunachron.

ATTEMPTED RELOCATION OF THE 1941 UNIVERSITY OF OKLAHOMA *PENTACERATOPS* QUARRY, SAN JUAN COUNTY, NEW MEXICO, *HUNT-FOSTER, R.K.,* rebecca.k.hunt@gmail.com, Museum of Western Colorado, Dinosaur Journey, 550 Jurassic Court, Fruita, Colorado 81521; *WILLIAMSON, T.E.,* New Mexico Museum of Natural History & Science, 1801 Mountain Road, NW, Albuquerque, New Mexico 87104-1375; and *LONGRICH, N.R.,* Department of Geology, Yale University, P.O. Box 208109, New Haven, Connecticut 06520-8109

In July of 1941, J. W. Stovall of the University of Oklahoma, with graduate student Don Savage and undergraduate Wann Langston, Jr., traveled to the San Juan Basin of New Mexico to collect fossils for the University of Oklahoma Museum. While on this trip they discovered the remains of the largest and most complete specimen of *Pentaceratops sternbergi* (OMNH 10165), a ceratopsian dinosaur that is probably endemic to the late Campanian of the San Juan Basin, New Mexico. This particular specimen is one of the largest ceratopsian dinosaurs ever collected (with a reconstructed skull length of over three meters) and the specimen is on permanent display at the Sam Noble Museum of Natural History in Norman, Oklahoma (OMNH). The specimen is certainly from either the Fruitland or Kirtland formations and is considered part of the Hunter Wash local fauna. Locating the historic 1941 *Pentaceratops* quarry will help to better constrain the geologic age of this particular specimen. Unfortunately, the precise location of this important find has been lost. Dr. Langston, documented the find to the best of his recollection, but the site has not been relocated. Evidence suggests that it is within an area now included in the Fossil Forest Research Natural Area near Coal Creek. However, some have suggested that the quarry may not be in the documented region, but rather north of this area, within what is now the Bisti/De-na-zin Wilderness Area. In April of 2009 Nick Longrich and ReBecca Hunt-Foster attempted to relocate the 1941 University of Oklahoma *Pentaceratops* Quarry, following the notes of Wann Langston, Jr. and archival photographs from the OMNH. While the location of this historic quarry was not certainly located during the course of this particular search, several other previous quarries were identified.

VOLCANIC STRATIGRAPHY OF THE WESTERN SIERRA BLANCA VOLCANIC FIELD, SOUTH-CENTRAL NEW MEXICO, *KELLEY, S.A.,* sakelley@ix.netcom.com, and *KONING, D.J.,* New Mexico Bureau of Geology & Mineral Resources, New Mexico Institute of Mining & Technology, 801 Leroy Place, Socorro, New Mexico 87801; *KEMPTER, K.A.*, 2623 Via Caballero del Norte, Santa Fe, New Mexico 87505; *ZEIGLER, K.,* Zeigler Geologic Consulting, Albuquerque, New Mexico 87123; *PETERS, L.*, New Mexico Bureau of Geology & Mineral Resources, New Mexico Institute of Mining & Technology, 801 Leroy Place, Socorro, New Mexico 87801; and *GOFF, F.*, Department of Earth & Planetary Sciences, University of New Mexico, Albuquerque, New Mexico 87131

A thick succession of trachyandesite, trachydacite, volcaniclastic sediments, and minor welded ash-flow tuffs is preserved on three N-S striking fault blocks on the west side of Sierra Blanca. The volcanic rocks on the eastern fault block, which includes Sierra Blanca, are composed of a basal thick (>250 m) sequence of pyroxene-phyric trachyandesite breccia and debris flow deposits overlain by a stack of plagioclase-phyric trachyandesite lava flows that are variably fine-grained to crystal-rich. The trachyandesite flows, with published $^{40}Ar/^{39}Ar$ ages of 29.3-37.3 Ma, are among the oldest volcanic rocks in the area. Volcaniclastic sediments are not common in the stacked lava flow section, but are preserved in paleo-channels cut in the upper part of the plagioclase-phyric trachyandesite. The volcanic rocks in middle fault block between Sierra Blanca and the Godfrey Hills are primarily the pyroxene-phyric trachyandesite breccia.

The western fault block, including the Godfrey Hills, exposes the younger part of the volcanic succession of the Sierra Blanca volcanic field. The oldest flows, found at low elevation on the south and west side of the Godfrey Hills, are dark-colored, porphyritic trachyandesite similar to the plagioclase-phyric trachyandesite on Sierra Blanca. Volcaniclastic channel fills are locally present between these flows. The dark-colored porphyritic trachyandesite flows are thinner and the volcaniclastic sedimentary rocks are thicker toward the north end of the hills. The dark-colored flows are overlain by (1) a discontinuous fine-grained, flow-banded, trachyte, (2) a thick volcaniclastic interval containing a few thin, discontinuous trachyandesite and trachydacite flows capped by a continuous trachyandesite flow, (3) a welded ash flow tuff (Palisades tuff; 28.67± 0.05 Ma), (4) a sparsely porphyritic trachyandesite with zones of breccia (28.59 ± 0.07 Ma), and (5) an upper fine-grained trachyte. The Palisades tuff is thicker at the north end of the Godfrey Hills. In addition, a thin tuff (tuff of Bucky Pasture) is preserved in the volcaniclastic interval in the northern Godfrey Hills. Thickness variations and the degree of welding of the tuffs suggest the presence of an undetected local caldera northeast of the Godfrey Hills.

COMPARISON OF ALLUVIAL FAN GEOMORPHOLOGY, SEDIMENTATION, AND EROSION ALONG THE EASTERN MARGIN OF THE TULAROSA BASIN, NEW MEXICO, *KONING*, *D.J.*, dkoning@nmt.edu, New Mexico Bureau of Geology and Mineral Resources, New Mexico Institute of Mining and Technology, 801 Leroy Place, Socorro, New Mexico 87801

This study compares two sets of alluvial fans along the eastern margin of the Tularosa Basin. Alluvial fans of the first set are gravelly and contain both debris flow and stream flow sediment. Fan-head trenching is confined adjacent to the mountain front. Fans belonging to the second set are derived from large mountain front drainages north of Alamogordo. These alluvial fans lack debris flow sediment, have less gravel and more clay, and exhibit entrenched, main-stem arroyos throughout their length. The longer arroyos perhaps relate to their finer-grained sediment and higher discharges from their respective mountain front canyons.

Both sets of alluvial fans experienced similar erosional and depositional histories in their proximal and medial areas. Erosion was concentrated in arroyos during 18-8 ka, with pedogenesis occurring on surfaces between arroyos. Widespread aggradation occurred between 8 and 3 ka on both sets of fans. On the first set of alluvial fans, stream flow sediment commonly transitions upwards into debris flow sediment, with an inset, coarse-grained deposit found below the debris flows. Stream flow and clayey-sandy sheet flood deposits characterize the second set of alluvial fans between 8 and 3 ka. Coarse-grained channel-fill deposits interfinger with clayey-silty, very fine- to medium-grained sand. Fine-grained sediment is generally bioturbated, internally massive, and has undergone weak pedogenesis. Pebbles in the fine-grained sediment are scattered or in thin to medium lenses. These observations indicate an aggrading fan landscape during the middle Holocene. Erosion occurred between 3 and 2 ka on both sets of alluvial fans. Another episode of aggradation occurred during 0.5-2.0 ka, which on the second fan set is marked by better stratification and slightly coarser texture than earlier Holocene deposits. North of Alamogordo, there was eolian reworking of sediment and localized, periodic arroyo formation and backfilling during 0.5-2.0 ka. These observations indicate that the late Holocene experienced episodes of surface instability, perhaps due, at least in part, to sparser grass and low-lying shrubs. Pronounced erosion has occurred on the proximal and medial parts of both alluvial fan sets during the past 100-150 years, resulting in prevalent gravel lag deposits and gully dissection.

CRETACEOUS DEPOSITIONAL ENVIRONMENTS AND SEQUENCE STRATIGRAPHY AT CERRO DE CRISTO REY, DOÑA ANA COUNTY, NEW MEXICO, *KRAINER, K.,* Karl.Krainer@uibk.ac.at, Institute of Geology and Paleontology, Innsbruck University, Innrain 52, Innsbruck, A-6020 Austria; *LUCAS, S.G., SPIELMANN, J.A.,* and *DURNEY, K.,* New Mexico Museum of Natural History, 1801 Mountain Road, N.W., Albuquerque, New Mexico 87104

Cretaceous marine and nonmarine strata of late Albian-middle Cenomanian age exposed around the Cerro de Cristo Rey uplift in southern Doña Ana County, New Mexico comprise a section ~350 m thick and are assigned to the (ascending order) Finlay, Del Norte, Smeltertown, Muleros, Mesilla Valley, Mojado (= "Anapra"), Del Rio, Buda and Mancos (= "Boquillas") formations. Macro- and microfossils from these strata indicate that the Finlay, Del Norte, Smeltertown, Muleros and Mesilla Valley formations are of late Albian age, whereas the Del Rio, Buda and Boquillas formations are of Cenomanian age. The base of the Cenomanian is most likely at a trangressive surface within the uppermost Mojado Formation. The late Albian (*Manuaniceras powelli* ammonite zone) to early Cenomanian (*Neophlycticeras hyatti* ammonite zone) sedimentary succession at Cerro de Cristo Rey consists of alternating fossiliferous limestone, shale with limestone and sandstone intercalations, and sandstone. Muddy limestone types are commonly wavy to nodular and represent deposits of an open marine shelf environment below wave base. Intercalated coquina beds rich in mollusc shells are interpreted as storm layers. Shale was deposited in an open shelf environment below or near wave base during periods of increased siliciclastic influx. Intercalated thin limestone and sandstone beds are suggested to be storm layers. The siliciclastic Mojado Formation is a regressive-transgressive succession formed in depositional environments ranging from lower shoreface to upper shoreface and even fluvial sediments, again overlain by shallow marine siliciclastics. Although the Washita Group section at Cerro de Cristo Rey is much thicker and displays some differences in facies, the succession shows similar transgressive and regressive trends when compared to the Washita Group of North Texas. Thus, we recognize eight unconformity-bounded depositional cycles in the Cretaceous section at Cerro de Cristo Rey, the upper Finlay Formation (youngest cycle of the Fredericksburg Group), lower Mancos Formation (base of Greenhorn cycle) and six Washita Group cycles: WA1 = Del Norte Formation, WA2 = Smeltertown Formation, WA3 = Muleros Formation, WA4 = Mesilla Valley Formation, WA 5 = most of Mojado Formation and WA6 = upper most Mojado and Del Rio and Buda formations.

A REGIONAL WATER TABLE MAP AND WATER LEVEL VARIATIONS IN THE SOUTHERN SACRAMENTO MOUNTAINS WATERSHED, NEW MEXICO, *Land, L.,* New Mexico Bureau of Geology and Mineral Resources, and the National Cave and Karst Research Institute, New Mexico Institute of Mining and Technology, 1400 Commerce Dr., Carlsbad, NM 88220; *RAWLING, G.*, New Mexico Bureau of Geology and Mineral Resources-Albuquerque office, New Mexico Institute of Mining and Technology, 2808 Central Ave. SE, Albuquerque, NM, 87106; *TIMMONS, S.*, New Mexico Bureau of Geology and Mineral Resources, New Mexico Institute of Mining and Technology, 801 Leroy Place, Socorro, New Mexico 87801

We have prepared a map of the regional water table in the southern Sacramento Mountains based on measurements made in water wells in March, 2008 and elevations of flowing springs and gaining reaches of streams. The aquifer system in the southern Sacramentos is developed primarily within the Yeso Formation, a heterogeneous unit composed of siltstone, mudstone, gypsum and fractured limestone. Water-bearing zones are distributed throughout the section. The system is recharged near the crest of the Sacramentos where high mountain springs discharge from small, highly-localized perched aquifers. Streamflow derived from these springs re-enters the groundwater system along losing reaches and may “daylight” multiple times along the flowpath, feeding springs at lower elevations. In most cases it is impossible to determine whether a measured water level corresponds to a perched aquifer or is part of the regional piezometric surface, and the distinction is probably irrelevant at the scale of observation of the entire watershed.

The regional hydraulic gradient is steepest near the crest of the Sacramentos, and progressively decreases to the east. Locally steeper gradients also occur in the vicinity of major faults. More broadly-spaced water level contours at lower elevations in the Sacramentos probably reflect mounding of the water table, in areas where the aquifer is recharged through sinkholes and karst fissures. Because eastward stratigraphic dip is greater than the regional hydraulic gradient, east of the Six-Mile Buckle the aquifer system is developed in karstic limestones of the San Andres Formation rather than the Yeso. The higher transmissivity of the San Andres limestone is reflected in a pronounced flattening of the water table as the southern Sacramentos aquifer merges with the artesian aquifer of the Roswell Artesian Basin.

Water level change maps show that during the period from 2006 to 2007, water levels in the high Sacramentos began rising in response to unusually intense monsoonal rains in fall, 2006. Water levels continued to rise in the subsequent two years, but the center of greatest increase migrated progressively farther to the east, suggesting that the 2006 monsoon event was continuing to be felt as an eastward diffusion of pressure head through the aquifer system.

THE SNOWY RIVER FORMATION IN FORT STANTON CAVE, NM: NEW RESULTS FROM RADIOMETRIC DATING AND HYDROLOGIC OBSERVATIONS OF THE WORLD'S LONGEST SPELEOTHEM, *LAND*, *L.*, lland@gis.nmt.edu, New Mexico Bureau of Geology & Mineral Resources, New Mexico Institute of Mining & Technology, and the National Cave & Karst Research Institute, 1400 Commerce Dr., Carlsbad, New Mexico 88220; *POLYAK, V.,* Department of Earth & Planetary Sciences, University of New Mexico, Albuquerque, New Mexico 87131; and *NEWTON*, *T.,* Mexico Bureau of Geology & Mineral Resources, New Mexico Institute of Mining & Technology, Socorro, New Mexico 87801

The Snowy River formation, a pool deposit located in a recently discovered passage in Fort Stanton Cave, New Mexico, may be the world's longest continuous cave deposit. The formation is composed of tufa-like white coralloid calcite lining an old subsurface stream channel, and currently extends from north to south for >7 km with its southern terminus still undefined. Core samples collected from the Snowy River deposit reveal a laminated internal structure, indicating episodic deposition of sub-millimeter scale calcite laminae during periods when the passage is flooded by $CaCO_3$-saturated water. The basal layer has been dated with U-Th techniques at only 836 years BP, indicating an abrupt change in climatic or hydrochemical conditions within the past millennium. The Snowy River passage has been intermittently flooded for the past two years during the southwest monsoon season, during which a thin film of new calcite was deposited. The source of water in the passage is unknown. Water level data loggers show abrupt disappearance of floodwaters during winter months when the monsoonal rains are over, suggesting a point source of recharge to the cave system via a sinkhole or losing stream, and possibly an as yet undiscovered second entrance to the south.

ADDITIONAL INVERTEBRATE ICHNOTAXA FROM THE LOWER PERMIAN HUECO GROUP, ROBLEDO MOUNTAINS, SOUTH-CENTRAL NEW MEXICO,

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Recent collecting of the Lower Permian Robledo Mountains Formation within the newly established Prehistoric Trackways National Monument and from its periphery near Las Cruces, New Mexico, has yielded several previously unrecorded ichnofossils, all of which are unusual. A resting impression has been found on a small slab of mudstone that contains associated *Paleohelcura* trackways. The morphology of the impression is consistent with an interpretation of having been produced by a scorpion. Neoichnological experiments have likewise demonstrated that scorpions can produce *Paleohelcura*. A bilobed ribbon trail preserved in convex hyporelief on a small mudstone slab has also been found. Arthropod appendage impressions appear outside of the lateral margins on either side of the lobes, indicating that this is a locomotion trail. Although this specimen resembles some relatively common ichnogenera, the presence of appendage impressions external to the margins is distinctive. This trace fossil probably represents a new ichnotaxon. Lastly, an enigmatic ovoid burrow preserved in convex hyporelief has been found on a mudstone slab that contains *Monomorphichnus* and tetrapod claw drags. It bears some resemblance to insect breeding chambers, which are more commonly found in Mesozoic or younger strata. There is one previous record of a possible insect chamber from the Robledo Mountains Formation, which differs in size and appearance from the ovoid burrow. Although ichnofossils from the Robledo Mountains Formation have been studied for nearly two decades, these newly discovered specimens indicate that continued collecting has a high potential for providing new or unusual ichnotaxa.

PRELIMINARY GEOLOGIC MAP OF THE CAPITOL PEAK SE QUADRANGLE WITH ILLUSTRATIONS OF UNCOMMON SURFICIAL FEATURES, NORTHERN TULAROSA BASIN, SOUTH CENTRAL NEW MEXICO, *LOVE, D.W.,* dave@gis.nmt.edu, New Mexico Bureau of Mines & Mineral Resources, New Mexico Institute of Mining & Technology, 801 Leroy Place, Socorro, NM 87801; *ALLEN, B.D.,* New Mexico Bureau of Geology and Mineral Resources-Albuquerque Office, New Mexico Institute of Mining and Technology, 2808 Central Ave., SE, Albuquerque, New Mexico 87106; and *MYERS, R.G.,* U.S. Army, IMWE-WSM-PW-E-ES, White Sands Missile Range, NM 88002

Near the northernmost floor of the Tularosa Basin, the demarcated Capitol Peak SE 7.5'-quadrangle is at the junction of three drainages (upper Salt Creek-Mound Springs, Carrizozo valley, and Three Rivers fan) and a western piedmont slope. This junction, along with an uncommon, sulfate-precipitating planar wetland, created a low-gradient surface that stalled the Carrizozo Malpais lava flow. The 5,200-year-old lava flow overrode alluvium and a complex environment of evaporite deposition and eolian features. In turn, these contrasting depositional processes continued after the lava flow and buried its margins and kipukas by up to 3 m of alluvial, evaporite, and loessal sediments. Post-lava alluvium accumulates on top of several types of groundwater-discharge gypsum and has spread out across the north-central part of the quadrangle. To the west, the broad valley of Salt Creek is incised up to 13 m below the level of maximum basin fill. The valley borders of Salt Creek consist of sparse, wind-deflated basin-fill exposures of fine-grained clastic and gypsic beds and cross-bedded pebbly sand channels, and moist fine-grained alluvial/eolian slopes where groundwater seeps just below the surface. The southwestern quarter of the quadrangle consists of a complex string of marshes, playas, blowouts, eolian dunes, and alluvial channels with discontinuous outcrops of basin fill. Stripped exposures of basin fill exhibit rare trackways of Pleistocene megafauna (mammoths?). Evidence of subsurface dissolution includes karst features and tilted basin-fill.

The two endemic populations of White Sands pupfish (*Cyprinodon tularosa*) live in Salt Creek and Malpais Spring and salt marsh on the quadrangle. In addition to gypsum, the modern brackish-to-saline springs, streams, and wetland environments precipitate halite, hexahydrite, thenardite and other soluble salts as widespread efflorescent surface accumulations, which are periodically removed by re-dissolution and wind deflation.

The uncommon surficial features related to accumulation by gypsum precipitation include megamounds, meandering raised-levee streams, platform marshes, raised-rim marshes, and hummocky rolling plains that appear to represent modification of previously deposited gypsum by eolian and/or dissolutional processes.

THE BURROW *ZOOPHYCOS* IN PENNSYLVANIAN STRATA OF THE MUD SPRINGS MOUNTAINS, SIERRA COUNTY, NEW MEXICO,

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Zoophycos comprises a diverse group of spreite burrows that range in age from Ordovician to Recent. It is generally thought to be the feeding trace of various worm-like animals and to indicate poorly oxygenated paleoenvironments with low sedimentation rates. There are only a few published reports of *Zoophycos* from New Mexico, and these are primarily from Carboniferous strata. We add to this sparse record an occurrence of *Zoophycos* at Whiskey Canyon in the Mud Springs Mountains. Here, the *Zoophycos* fossils occur in a 0.6-m-thick bed of coarse crinoidal limestone (crinoidal wackestone) near the top of the Elephant Butte Formation of Thompson, which is near the top of the Red House Formation of Kelly and Silver.

We collected a representative specimen preserved in convex hyporelief. It shows clockwise, alectorurid ("cock's tail") spreite on the bedding surface. Because neither a marginal tube, nor a vertical generating tunnel is preserved, the specimen can only be assigned to cf. *Zoophycos* ichnosp. The overall width is about 27 cm, which is average size for Paleozoic forms. *Zoophycos* is a classic trace fossil long interpreted as characteristic of relatively deep, poorly oxygenated sea bottoms. However, protected lagoonal settings of moderate depth are also known to produce *Zoophycos*, and we interpret the Mud Springs record as a shallow marine setting with restricted circulation. The *Zoophycos* bed is in the middle of a 20-m-thick succession of wavy to even bedded limestone units (0.6-2.8 m thick) and covered intervals (0.6-2.9 m thick) that probably represent shale intervals. These limestone units are all dark gray, micritic and contain some chert in the lower and upper part. The lime mudstone in the upper part of the section, above the *Zoophycos* bed, is bioturbated. Common fossils are brachiopods and crinoid fragments. The muddy texture of the limestone units indicates deposition in a low-energy shelf environment below the storm wave base.

EXCEPTIONALLY-PRESERVED PALEOFLORA FROM THE UPPER TRIASSIC CHINLE GROUP, SANTA FE COUNTY, NEW MEXICO, *LUCAS*, *S.G.*, spencer.lucas@state.nm.us, and *SPIELMANN*, *J.A.*, New Mexico Museum of Natural History, 1801 Mountain Road NW, Albuquerque, New Mexico 87104

A recently discovered locality in the Trujillo Formation, Chinle Group, south of Lamy, Santa Fe County, New Mexico (T12N, R11E), yields a remarkably well-preserved Upper Triassic paleoflora. The fossil plants come from two stratigraphic levels in an ~1-m-thick bed of muddy, micaceous fine-grained sandstone and siltstone. Locally, the Trujillo Formation is ~24 m thick, and the plant levels are ~18 m below its contact with the overlying Petrified Forest Formation. We interpret the plant-bearing bed as a shallow lacustrine deposit that developed on the floodplain surface between Trujillo channel courses. The paleoflora is dominated by carbonized compressions of two taxa, the palmate fern *Phlebopteris smithii* (Daugherty) (including complete, monopodial palmate leaves) and the bennettitalean *Otozamites powelli* (Fontaine). Much less common plants include the fern *Todites fragilis* Daugherty and the horsetail *Neocalamites*. The quality of preservation of this macroflora is exceptional, encompassing epidermis, sporangia and spores. This paleoflora is characteristic of the *Dinophyton* floral zone, yet it is stratigraphically high for an occurrence of this floral zone. Thus, the overlying *Sanmiguelia* floral zone normally is found in Trujillo Formation strata. Nevertheless, near Las Vegas in San Miguel County, *Sanmiguelia* has been found below the Trujillo Formation, in the uppermost Garita Creek Formation. The Lamy locality thus adds to evidence that there is a stratigraphic overlap between the *Dinophyton* and the *Sanmiguelia* floral zones in the middle part of the Chinle Group.

PRECISE AGE OF THE KINNEY BRICK QUARRY LAGERSTÄTTE, PENNSYLVANIAN OF THE MANZANITA MOUNTAINS, NEW MEXICO, *LUCAS*, *S.G.,* spencer.lucas@state.nm.us, New Mexico Museum of Natural History, 1801 Mountain Road N.W., Albuquerque, New Mexico 87104; *KRAINER*, *K.,* Institute of Geology and Paleontology, Innsbruck University, Innsbruck, Austria; *ALLEN*, *B.D.,* New Mexico Bureau of Geology and Mineral Resources, Socorro, New Mexico 87801; *BARRICK*, *J.E.,* Department of Geosciences, Texas Tech University, Lubbock, Texas 79409; and *VACHARD*, *D.*, Université des Sciences et Technologies de Lille, Villenueve d'Ascq, France

Located in the Manzanita Mountains of central New Mexico, the Kinney Brick quarry is a world famous Late Pennsylvanian fossil locality in an estuarine deposit. The quarry is located in the Atrasado Formation (locally designated the "Wild Cow Formation" in previous studies), a regionally extensive stratigraphic unit of well-established Late Pennsylvanian age, based on fusulinid biostratigraphy. However, the precise age of the Kinney quarry deposit has been difficult to determine because virtually all of the fossils from the quarry are not precise age indicators. Thus, the age assigned to the Kinney quarry (middle Virgilian) has long been based more on its inferred lithostratigraphic position than on biostratigraphic indicators at the quarry. This age assignment has relied on USGS geologic mapping (especially USGS Map I-968), which located the Kinney quarry stratigraphically high in Myers' (1973, USGS Bulletin 1372-F) "Pine Shadow Member" of the Wild Cow Formation, a local map unit that fusulinid biostratigraphy (in other parts of the mountain range) indicates is of middle Virgilian age. In contrast, we have developed three datasets that indicate the Kinney quarry is older---stratigraphic position, fusulinids and conodonts. Our detailed local lithostratigraphic studies coupled with regional stratigraphic investigations indicate the Kinney quarry is in the Tinajas Member of the Atrasado Formation, so it is stratigraphically lower (i.e., very near the base of Myers' "Pine Shadow Member") than suggested by previously published maps. A laterally extensive fusulinid-bearing limestone a few meters below the level of the Kinney quarry yields an early-middle Missourian fusulinid assemblage consisting of *Tumulotriticites* cf. *T. tumidus* and species of *Triticites*: *T.* cf. *T. planus*, *T.* cf. *T. myersi* and *T.* ex gr. *T. ohioensis*. Conodonts from the basal beds of the Kinney quarry are also Missourian species, though they indicate an age slightly younger than do the fusulinids. Thus, the Kinney conodont fauna is dominated by members of the *Idiognathodus symmetricus* - *I. multinodosus* group, species of which appear in the middle Missourian and range into the Virgilian (middle Kasimovian into the base of the Gzhelian).We conclude that the Kinney quarry Lagerstätte is of Missourian age, most likely middle Missourian.

REVISED PENNSYLVANIAN LITHOSTRATIGRAPHY IN THE MANZANO MOUNTAINS, NEW MEXICO, *LUCAS*, *S.G.,* spencer.lucas@state.nm.us, New Mexico Museum of Natural History, 1801 Mountain Road N.W., Albuquerque, New Mexico 87104; and *KRAINER*, *K.,* Institute of Geology and Paleontology, Innsbruck University, Innrain 52, Innsbruck, A-6020 Austria

The Pennsylvanian section at Priest Canyon (sec.7, T3N, R5E, Valencia County) includes the type sections of units named by Myers (USGS Bulletin 1372-F) and long applied to Pennsylvanian strata throughout the Manzano and Manzanita Mountains. Detailed restudy indicates it is very similar to the Pennsylvanian section in the Cerros de Amado, ~60 km to the SW, so, stratigraphic nomenclature introduced by Thompson in 1942 can be applied at Priest Canyon. The base of this section is the ~ 70 m thick Sandia Fm, mostly covered slopes and beds of sandstone, limestone and conglomerate that rest on Proterozoic basement. The overlying Gray Mesa Fm (= Los Moyos Limestone) is ~190 m thick and mostly cherty limestone, divided into three members (ascending): (1) Elephant Butte Mb, ~ 24 m of limestone and shale; (2) Whiskey Canyon Mb, ~86 m of cherty limestone; and (3) Garcia Mb, ~83 m of non-cherty limestone and shale with lesser amounts of cherty limestone, sandstone and conglomerate. The overlying Atrasado Fm (= Wild Cow Fm) is ~ 272 m thick and divided into eight members (ascending): (1) Bartolo Mb, ~ 66 m of slope-forming shale with thin beds of sandstone, limestone and conglomerate; (2) Amado Mb, ~ 8 m of bedded, cherty, brachiopod-rich limestone; (3) Tinajas Mb, ~125 m of shale with interbedded limestone and sandstone; 4) Council Springs Mb, ~ 22 m of mostly algal limestone without chert; (5) Burrego Mb, ~18 m of arkosic red beds and limestone; (6) Story Mb, ~ 7 m of limestone; (7) Del Cuerto Mb, ~ 15 m of arkosic red beds and limestone; and (8) Moya Mb, ~ 11 m of bedded limestone and shale. At the top of the Pennsylvanian section, the Bursum Formation is at least 30 m of interbedded red-bed mudstone, sandstone, conglomerate and limestone. At their type sections, Myers members of the "Wild Cow Fm" clearly are fusulinid-based, biostratigraphic units, not lithostratigraphic units, as their contacts are not drawn at laterally traceable lithologic changes. Thus, Sol se Mete Mb = Missourian fusulinids (= Bartolo-lower Tinajas), Pine Shadow Mb = early Virgilian fusulinids (=upper Tinajas-lower Burrego) and La Casa = middle-late Virgilian fusulinids (=upper Burrego-Moya). We thus recommend abandonment of all Myers Pennsylvanian lithostratigraphic terms because they are either synonyms of earlier named units or do not identify useful lithostratigraphic units.

GEOLOGIC COMPILATION MAP OF THE LOWER PECOS ALLUVIAL VALLEY, BITTER LAKE TO BOTTOMLESS LAKES AREA, CHAVES COUNTY, NEW MEXICO, *McCRAW*, *D.J.*, djmc@nmt.edu, New Mexico Bureau of Geology & Mineral Resources, New Mexico Institute of Mining & Technology, 801 Leroy Place, Socorro, NM 87801

A recent compilation of NMBGMR-STATEMAP geologic mapping of the Bitter Lake, South Spring, and Bottomless Lakes 7.5-min. quadrangles in the Lower Pecos valley depict a late Pleistocene- Holocene floodplain, flanked to the west by Plio-Pleistocene alluvial terraces, dissected by the Arroyo Hondo. These are cut into Permian limestone of the San Andres Formation to the west, overlain by the thick evaporite sequence of the Artesia Group. The extensive gypsum beds of the Seven Rivers Formation, riddled with karstic depressions and sinkholes, underlie the valley and form the eastern bluffs of the valley margin. Many of these sinks serve as conduits for numerous springs derived from the underlying artesian aquifer, and are oriented roughly parallel to or orthogonal to the SW-NE trending regional structural buckles.

Three alluvial terraces are mapped west of the Pecos valley: remnants of the Plio–Pleistocene Blackdom Terrace, the broad mid-late Pleistocene Orchard Park Terrace, and the late Pleistocene Lakewood Terrace. The inset modern Pecos floodplain, reaching a maximum thickness of ~45 m along the western margin, is comprised of late Pleistocene braided stream deposits, and 3 Holocene meanderbelts. A series of collapse depressions extending roughly 14 km on the eastern valley margin, also contain late Pleistocene-mid Holocene Pecos River alluvium.

The Arroyo Hondo has built extensive fans onto the Orchard Park Terrace throughout the Pleistocene. Gravel pits in Arroyo Hondo fan deposits exhibit decreasing pedogenic carbonate development from south to north, implying a northward shift of the river to its present entrenched channel. A large late Pleistocene distributary fan pushed the Pecos River eastward into the collapse depressions, allowing the early-mid Holocene Arroyo Hondo to build its first two of three meanderbelts across the entire Pecos floodplain. Two Pecos River meanderbelts have since cut through these Rio Hondo alluvial deposits.

DIMETRODON (EUPELYCOSAURIA: SPHENACODONTIDAE) FROM THE UPPER PERMIAN ABO FORMATION TORRANCE COUNTY, NEW MEXICO, *McKEIGHEN, H.W.,* hmloslunas1@msn.com, and *McKEIGHEN, K.L., Jr.,* 46 Cuerro Lane Los Lunas, N.M. 87031; *LUCAS, S.G.*, *SPIELMANN, J.A.*, and *HARRIS, S.K.*, New Mexico Museum of Natural History and Science, 1801 Mountain Rd. NW, Albuquerque, NM 87104-1375

The sail-backed basal ("pelycosaurian"-grade) synapsid *Dimetrodon* is one of the most distinctive basal amniotes of the Permian Period. Outside of Texas, the genus has sparse records in New Mexico, Utah, Arizona and Germany. We add to the sparse record of *Dimetrodon* from New Mexico a recently discovered specimen from the Abo Pass area, Torrance County, consisting of a distinctive elongate neural spine cataloged as NMMNH P-58748. From the lower part of the Cañon de Espinoso Member of the Abo Formation near the Abo mine (NMMNH locality 7765), the incomplete spine has a figure-eight (or dumbbell-shaped) cross-sectional outline, a minimum dorsoventral height of 125 mm and a maximum transverse width of 12 mm. Slender, elongate neural spines with anterior and posterior grooves (forming a figure-eight cross-section) are particularly characteristic of the genus. However, NMMNH P-58748 is too incomplete to assign to a species of *Dimetrodon*, though it clearly pertains to a small specimen of the genus.

This fossil of *Dimetrodon* is the fourth record of the genus from New Mexico. Two are from Abo Formation red beds in the Jemez Mountains area of northern New Mexico and a third is from the Loma de las Cañas area, Socorro County. During the time of Abo deposition (middle Wolfcampian-early Leondardian), the *Dimetrodon* locality reported here was ~ 170 km from the seashore and near the flanks of the Pedernal uplift of the ancestral Rocky Mountain orogeny. This *Dimetrodon* thus lived in an inland habitat, and this fits the distribution of *Dimetrodon* fossils in the Abo Formation in New Mexico, which is consistent with it having been a fully terrestrial inland and upland predator. Additional discoveries of *Dimetrodon*, like that reported here, are needed to fully establish its paleogeographic and paleoenvironmental range, though we expect that full explanation of its varied abundance will remain elusive for some time to come.

EARLY PERMIAN VERTABRATE FOSSILS FROM THE ABO FORMATION AT THE ABO MINE, ABO PASS, NEW MEXICO, *McKEIGHEN, K.L., Jr.*, kentheartist1@msn.com, and *McKEIGHEN, H.W.*, 46 Cuerro Lane, Los Lunas, New Mexico 87031, *LUCAS, S.G., SPIELMANN, J.A.,* and *HARRIS, S.K.,* New Mexico Museum of Natural History and Science, 1801 Mountain Rd. NW, Albuquerque, NM 87104-1375

The Abo Mine (Scholle Mine) is a red-bed copper deposit developed in the Scholle Member of the Lower Permian Abo Formation near Abo Pass in Torrance County, New Mexico. It was first worked from 1914 to 1919 and again during the mid 1940's for both WWI and WWII war efforts. Total production of copper, for both periods of operation, was approximately $250,000. The difficulty and cost associated with extracting the copper caused a discontinuation of mining efforts after WWII. However, the mine is an important fossil locality. Thus, Charles B. Read of the U. S. Geological Survey collected petrified wood and *Calamites* specimens from the mine area in the mid 1940's. One of us (KLM) visited the mine in April 2009 and collected the first vertebrate fossil from the area, a partial metatarsal. Additional field work identified highly fossiliferous sites at the Abo Mine, including a stream channel lag associated with an open pit mine. This lag consists of both consolidated sandstone, containing up to 50% or more bone, and an unconsolidated mudstone, with loose bone. The vertebrate fossils from the mine are dominated by bones of the pelycosaur-grade synapsid *Sphenacodon*. The most diagnostic elements are vertebrae with tall, blade-like neural spines. The presence of *Sphenacodon* within the assemblage indicates an Early Permian (Coyotean-Seymoran: Wolfcampian) age.

THE SACRAMENTO MOUNTAINS WATERSHED STUDY: PRE-TREATMENT ANALYSES AND CONSIDERATIONS, *NEWTON*, *B.T.*, talon@gis.nmt.edu, New Mexico Bureau of Geology and Mineral Resources, New Mexico Institute of Mining and Technology, 801 Leroy Place, Socorro, New Mexico 87801; *FERNALD, A.,* and *GARDUÑO*, *H.*, Animal and Range Sciences Dept. New Mexico State University, Las Cruces, New Mexico 88003; and *KLUDT*, *T.,* New Mexico Bureau of Geology and Mineral Resources, New Mexico Institute of Mining and Technology, 801 Leroy Place, Socorro, New Mexico 87801

There is widespread interest in removing trees to increase water yields in southern New Mexico. The Sacramento Mountain watershed study focuses on: 1) characterization of water budgets of a mixed conifer forested watershed in the Southern Sacramento Mountains, NM; 2) assessment of the effects of tree thinning on the watershed hydrologic system; and evaluation of total watershed surface and groundwater outflows. Pre-treatment analyses have been used to develop a conceptual model of the hydrogeologic system within the study area and to identify inputs and outputs to the local water budget.

Taking place within the bounds of a broader regional study, this project addresses two spatial scales: the 750 acre Three L Canyon watershed and 90x90m study plots. The watershed is located on private property near James Canyon approximately 20 km east of Cloudcroft. There are two springs in Three L Canyon, but no perennial streams that transport water outside the watershed. Elevations within the study area range from 2300 to 2600 m above sea level. Tree densities in the study area average 312 trees/acre, with Douglas-fir being the most common species. Thinning slated to begin in fall 2010 will reduce the average tree density to 40 – 60 trees/acre.

Well logs from three observation wells were used to characterize the subsurface geology. Measurements begun in mid-2008 include field surveys, soil and water chemistry analyses, and automated sensor data. Automated data collected from multiple sites include: spring discharge, valley groundwater levels, soil moisture, matric potential, canopy throughfall, and precipitation and climate data.

Well logs, groundwater level data, and geochemical data indicate a complex multilayered groundwater system. Chloride and stable isotope profiles in soils suggest rapid movement of water through the thin rocky soils, indicating high infiltration rates and low runoff. Spring hydrographs, stable isotope data, and water chemistry suggests that discharge from the two springs largely comes from outside of the watershed and are therefore considered to be inputs. Other inputs include local precipitation and inflowing groundwater. Outputs include evapotranspiration, and both shallow and deep groundwater flow.

THE STABLE ISOTOPIC COMPOSITIONS OF NATURAL WATERS IN THE SOUTHERN SACRAMENTO MOUNTAINS, NM: IMPLICATIONS FOR CLIMATIC AND HYDROGEOLOGIC CONTROLS ON GROUNDWATER RECHARGE, *NEWTON, B.T.,* talon@gis.nmt.edu, New Mexico Bureau of Geology and Mineral Resources, New Mexico Institute of Mining and Technology, 801 Leroy Place, Socorro, New Mexico 87801; *RAWLING, G.,* New Mexico Bureau of Geology and Mineral Resources-Albuquerque Office, New Mexico Institute of Mining and Technology, 2808 Central Avenue SE, Albuquerque New Mexico 87106*; TIMMONS, S.,* and *KLUDT, T.,* New Mexico Bureau of Geology and Mineral Resources, New Mexico Institute of Mining and Technology, 801 Leroy Place, Socorro, New Mexico 87801

Groundwater flow in the southern Sacramento Mountains is related to regional fracture systems within the highly heterogeneous Yeso Formation. As a part of the Sacramento Mountains hydrogeology study, water from precipitation, streams, springs, and wells was sampled and analyzed for the stable isotopes of oxygen and hydrogen.

Stable isotope data for precipitation were used to develop a local meteoric water line (LMWL). Seasonal fluctuations along the LMWL define expected isotopic compositions for summer and winter precipitation. An elevation effect was observed for summer precipitation but not for winter precipitation. Over the three years that precipitation was collected, the Sacramento Mountains experienced two discrete recharge events due to above average precipitation during the summers of 2006 and 2008. These recharge events resulted in an increase in groundwater levels over most of the study area.

Stable isotope data for spring and well water in the high mountains indicate a dual porosity system. The isotopic compositions of water in the mobile hydrologic system, which is associated with fractured limestone and dolomite, plot along an evaporation line (slope ~5.5) that intersects the LMWL in the range of expected winter values. This trend suggests that the primary source of groundwater recharge is snow melt that undergoes mixing and evaporation in fractures and mountain streams. The isotopic compositions of water in immobile regions, which are probably located in non-fractured portions or smaller fractures within the Yeso Formation, plot along the LMWL and appear to be controlled by the elevation of local precipitation.

The isotopic composition of most springs sampled approximately one month after the 2006 monsoon season plotted near the LMWL. Tritium and water chemistry data indicates that most of this water was not derived from 2006 monsoons. The isotopic compositions of spring waters changed with time over the next 18 months, shifting away from the LMWL, until they plotted along the evaporation line. Then the isotopic composition of spring waters began to shift again towards the LMWL shortly after the precipitation events in 2008. We interpret the isotopic shift towards the LMWL as a result of immobile waters being flushed into the mobile hydrologic system due to these extreme summer precipitation events.

A NEW ASSEMBLAGE OF UPPER CRETACEOUS SELACHIANS: HOSTA TONGUE OF THE POINT LOOKOUT SANDSTONE, BERNALILLO COUNTY, NEW MEXICO,
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A new assemblage of Santonian selachians from the eastern side of the Rio Puerco was collected in the summer of 2009. This faunal assemblage was found in unconsolidated sand through both surface picking and screening, and is located in the lower Santonian Hosta Tongue, which is the lowest horizon of the Point Lookout Sandstone, which is the lowest of the stratigraphic units within the Mesa Verde Group. The sands were collected in various locations throughout an area of approximately one acre, and then screen-washed using a 1 mm mesh. This process yielded in excess of 200 teeth, representing at least four orders. Within these orders, at least 16 genera can be recognized, including three undescribed taxa that are new to the New Mexican selachian record. The teeth picked from the surface show much wear due to exposure, but the screen-washed teeth show little evidence of prior transport. Besides teeth, several dermal ossicles of selachians were also found, and teleost fossils, both teeth and vertebrae, were present in some abundance. This assemblage is dominated by lamniform species, especially those of *Scapanorhynchus, Squalicorax*, and *Cretolamna*. Rajiformes (*Pseudohypolophus*) and Pristiformes (*Ischyrhiza*) are also fairly common. Included in this assemblage are several shell fragments of soft-shell turtle (Trionychidae) and two pieces of very small reptile teeth. A listing of the selachian fauna would include three species of *Squalicorax,* as well as *Cretolamna, Ptychotrygon, Cantioscyllium, Cretoxyrhina, Scapanorhynchus,* Hybodontidae, *Cretodus, Ptychodus,* and *Odontaspis.*

PALEOMAGNETIC DATA FROM LATE MIOCENE LOBATO BASALT FLOWS ADJACENT TO THE SANTA CLARA FAULT SYSTEM, CHILI QUADRANGLE, RIO ARRIBA COUNTY, NEW MEXICO, *PETRONIS, M.S.*, mspetro@nmhu.edu, and *LINDLINE*, *J.*, Environmental Geology Program, Natural Resource Management Department, New Mexico Highlands University, PO Box 9000, Las Vegas, New Mexico 87701

The Late Miocene Lobato Formation comprises predominantly fine-grained and vesicular olivine- and plagioclase-phyric alkaline basalts. Lobato volcanism represents some of the pre-caldera mafic volcanism in the Jemez Mountain Volcanic Field and coincided with an episode of crustal extension in the Espanola Basin. We examined a 100 meter thick sequence of the Lobato Formation on the north side of Arroyo de la Plaza Larga Canyon. Here, the Lobato flows are subhorizontal to gently dipping for nearly 2 kilometers southeast from the Cerro Roman volcanic center, then dip steeply about a roughly northwest trending axis, then abut and dip modestly against the Santa Clara fault – a major structure on the western margin of the Espanola Basin. We studied the disposition of these lava flows and attempted to distinguish between (1) lava flow emplacement into a paleovalley which existed in the late Miocene along the Santa Clara fault system or (2) post-emplacement drag folding against the Santa Clara fault. Paleomagnetic data were collected from sixteen sites along a transect representing the arcuate structure in order to conduct a paleomagnetic fold test. Remanent magnetizations were measured using a AGICO JR6-A Dual-Speed magnetometer at the New Mexico Highlands University paleomagnetic-rock magnetic laboratory. Specimens were progressively AF demagnetized in 10 to 15 steps to a maximum field of 120 mT to isolate the geological important characteristic remanent magnetization. Paleomagnetic data reveal a single component magnetization that decays to the origin with less than 10 percent of the natural remanent magnetization remaining after treatment in 120 mT fields. In situ results from sites located in the subhorizontal hinge zone and those from the east fold limb yield statistically indistinguishable remanence directions. Following structural correction based on the strike and dip of the individual flows, the dispersion between the two data sets increases, indicating a negative paleomagnetic fold test. We argue that the lava flows were emplaced into a paleovalley of considerable relief adjacent to the Santa Clara Fault during the late Miocene. These data indicate that the Santa Clara Fault was a prominent structure that influenced the paleotopography of the western margin of the Rio Grande Rift in the late Miocene.

PETROLOGIC CHARACTERISTICS OF GRANITIC PHASES WITHIN THE HERMIT'S PEAK BATHOLITH, *PITRUCHA, R.M.*, rpitruch@live.nmhu.edu, and *LINDLINE, J.*, New Mexico Highlands University, Environmental Geology Program, Natural Resources Management Department, Las Vegas, New Mexico 87701

We report petrographic and geochemical data from granitic phase within the Hermit's Peak batholith, a Proterozoic plutonic-metamorphic complex in the southern Sangre de Cristo Mountains northwest of Las Vegas, New Mexico. We recognize at least three distinct intrusive phases. Early granitoid intrusions formed centimeter- to meter-wide coarse-grained tabular sheets and layers within Paleoproterozoic host rock gneisses. The intrusions were deformed during isoclinal folding along with their host rocks, suggesting that these early granites are pre- or syntectonic with contractional deformation associated with Yavapai-Mazatzal collision. These granites show a fine- to medium-grained anhedral granular texture with quartz microstructures indicative of dynamic strain and solid state deformation, including undulose extinction, serrated grain boundaries, and ribbon texture. The Hermit's Peak granite, a supposed 1.4 Ga "anorogenic" granite, is a foliated fine- to medium-grained anhedral granular granite. Aligned interstitial minor biotite and magnetite define the foliation, which is variable at the outcrop-scale. The relationship between the granite foliation and host rock foliation has not been concluded. Strain-related microstructures are rare, suggesting that the Hermit's Peak granite fabric developed syntectonically within a local or more regional deformation event. Discordant dikes and stocks of pegmatitic alkali granite intruded the other units. The pegmatites are megacrystic with a preponderance of alkali feldspar and quartz. All of the granitic phases are nearly saturated with respect to alumina. The granitic sheets and foliated granite have overlapping major and trace element values, while the pegmatites have higher weight percent SiO_2, higher elemental Ba and Rb, and lower elemental Zr and Zn. The Hermit's Peak batholith is located in the transition zone between the Yavapai and Mazatzal Precambrian provinces. Radiometric age determinations are needed to constrain the timing of magmatism and fabric development and help resolve whether the Mazatzal orogeny was a discrete or protracted tectonic event.

GEOCHRONOLOGY, GEOCHEMISTRY AND TECTONIC OCCURRENCE OF TRAVERTINE DEPOSITS IN NEW MEXICO AND ARIZONA, *PRIEWISCH, A.,* arp2301@unm.edu, *CROSSEY, L.J.*, *EMBID, E.*, and *KARLSTROM, K.E.*, Department of Earth & Planetary Sciences, University of New Mexico, Albuquerque, New Mexico 87131

CO_2 springs and associated travertine deposits offer a unique tool to better understand Cenozoic paleohydrology, paleoclimate, and tectonics. Travertine accumulations represent places of persistent and significant mantle CO_2 degassing linked to their tectonic environment. Their geochemistry records paleohydrology and paleoclimate, and hence precise dates on these rocks offer a productive venue for evaluating Cenozoic tectonic and climate histories. Recent U/Th dates from Springerville, Arizona, show that: 1) travertine deposition began before 350 ka, with major accumulations occurring in cycles of approximately 70 ka; 2) the CO_2 of modern travertine-depositing springs is partly derived from the mantle based on $^3He/^4He$ and $CO_2/^3He$ ratios; and 3) incision rates of the Little Colorado River increased markedly in the last 100 ka. On-going work at Mesa Aparejo and Mesa del Oro, New Mexico, reveals similar large magnitude, but less-studied, travertine deposits. Proposed research methods involve radiogenic isotope geochemistry for U-series dating of the travertine, stable isotope geochemistry to evaluate biogenic influences and paleoclimate/paleohydrology fluctuations, geochemical analysis with XRF and electron microprobe, a detailed petrographic study, mapping, and GIS analysis. The data of the three locations will be compared, systematically analyzed, and put into context with the paleohydrology, paleoclimatology and neotectonic processes of the Rio Grande rift - Colorado Plateau region.

GEOLOGIC MAP OF THE SOUTHERN SACRAMENTO MOUNTAINS, OTERO AND CHAVEZ COUNTIES, NEW MEXICO, *RAWLING, G.C.*, geoff@gis.nmt.edu, New Mexico Bureau of Geology and Mineral Resources-Albuquerque Office, New Mexico Institute of Mining and Technology, 2808 Central Ave., SE, Albuquerque, New Mexico 87106

The NMBGMR has recently completed a new 1:100,000-scale geologic map of the southern Sacramento Mountains. The mapped area extends from Alamogordo on the west to Dunken on the east, and from the southern border of the Mescalero Apache Reservation to the northern border of McGregor Military Range. The compilation is comprised of new mapping from the Statemap program, mapping funded under the Sacramento Mountains Hydrogeology Study, and existing mapping by Pray (1961) along the western escarpment and Black (1973) near Piñon. It covers approximately twenty-four 7.5'quadrangles never before mapped at 1:24,000-scale.

The important units exposed over the majority of the map area are the Permian Yeso and San Andres formations. The Yeso formation consists of red and yellow siltstones and mudstones, and grey carbonates. It is exposed, generally poorly, along valley bottoms and lower valley walls throughout the north-central part of the map area, along the upper flanks of the western escarpment and in the Sacramento River drainage, and in isolated outcrops in the southeast. Springs are very common below the contact between the Yeso and San Andres Formations. Following Kelley (1971), three members of the San Andres formation were mapped, except in the highest elevations, where exposures are poor and vegetation precluded aerial photo identification.

Major structures are 1) the Tertiary Alamogordo Fault, along which the east-tilted mountain block was uplifted; 2) the Tertiary Sacramento River fault zone, composed of west-side-down, southeast-trending normal faults that define the Sacramento River drainage; 3) the southern termination of the Dunken-Tinnie anticlinorium, a north-south zone of tight folding and associated faults with variable dip-slip and possible strike-slip motion; and 4) the southwestern termination of the Six-Mile and Y-O buckles, right-lateral strike-slip faults that cross the Pecos Slope. The latter three structures are only constrained to be younger than Permian in age. Complex faults and folds in the southeast probably resulted from the interaction of Tertiary block-faulting with existing northeast- trending basement structures. We interpret the northeast–trending segment of the Rio Peñasco near Mayhill to be a fault, and it is a hydrologically significant boundary.

KEYNOTE PRESENTATION: HYDROGEOLOGY OF THE SOUTHERN SACRAMENTO MOUNTAINS, *RAWLING, G.C.*, geoff@gis.nmt.edu, New Mexico Bureau of Geology and Mineral Resources-Albuquerque Office, New Mexico Institute of Mining & Technology, 2808 Central Avenue SE, Albuquerque, New Mexico 87106

The southern Sacramento Mountains are an important source of recharge to the Lower Pecos Valley, Roswell Artesian Basin, and Salt Basin aquifers. Significant declines in water levels in wells, spring and stream flow have occurred in the past 15 years. In response, the Otero Soil and Water Conservation District and the NMBGMR initiated a multi-scale study of the regional hydrogeology to delineate areas and timing of ground water recharge, determine direction and rates of ground water movement, and understand interactions between different aquifers and the ground water and surface water systems in the mountains.

The Yeso Formation, which consists of layers of limestone, dolomite, sandstone, and siltstone, is the primary aquifer in the study area. Fractured limestones and dolomites are the main source of water for most springs and wells in the southern Sacramento Mountains. Recharge primarily occurs in the high mountains west of Mayhill where the Yeso Formation is exposed at the surface. Stable isotope data suggests that snow melt usually contributes significantly more to ground water recharge than summer precipitation. However, extreme summer precipitation events, such as those that occurred in 2006 and 2008 do recharge the ground water system, resulting in significant increases in water levels in wells and spring discharge.

The ground water system in the high mountains west of Mayhill is characterized by several fracture-controlled leaky perched aquifers that are interconnected by regional fracture networks and the surface water system. Snow melt in the high mountains recharges shallow perched aquifers that discharge at springs that feed streams and ponds where evaporation occurs. Water in ponds and streams may then recharge another shallow perched aquifer, which again may discharge at a spring at a lower elevation. This cycle may occur several times until the water is deep enough to be isolated from the surface water system. A deeper regional aquifer may exist in this area. East of Mayhill along the Pecos Slope, regional ground water flow is dominantly to the east towards the Roswell Artesian Basin. Some ground water also flows to the southeast towards the Salt Basin and to the west into the Tularosa Basin.

A SALINIZATION STUDY WITHIN THE SAN ACACIA REGION, SEVILLETA NATIONAL WILDLIFE REFUGE (SNWR), NEW MEXICO, *REYES*, *F.*, Frreyes@miners.utep.edu, Department of Environmental Sciences, University of Texas at El Paso, El Paso, Texas 79968; *ADELBERG*, S., Department of Geological Sciences, Brown University, Providence, Rhode Island 02912; *WILLIAMS*, *A.*, *CROSSEY*, *L.J.*, and *KARLSTROM, K.E.*, Department of Earth and Planetary Sciences, University of New Mexico, Northrop Hall, Albuquerque, New Mexico 87131

The arid climate of the American southwest poses concerns in water management for both ground and surface waters in the Rio Grande rift corridor. High salinity and elevated trace element concentrations tend to impair water quality; hence identifying sources of these contaminants remains an important ongoing challenge. Geochemical studies show an increase in salinity in the Rio Grande near San Acacia, located at the southern end of the Albuquerque Basin. Alternate models contend that: A) deep-seated faults within the rift provide conduits for the ascent of deeply-derived saline fluids, and B) upwelling of sedimentary basin brines takes place at interbasin constrictions. We used aqueous geochemical techniques (field parameters, major and trace elements, Cl/Br ratios, $\delta^{18}O$ and δD) and geochemical modeling to identify salinity components in the middle Rio Grande basin. An integrated study of spring geochemistry centered at the SNWR with factors related to poor water quality will allow for an improved comprehension of natural contaminants in the Rio Grande hydrochemical system. Results show that the Rio Salado Box (RSB) and San Acacia (SA) springs are both major salinity inputs. SA contains the highest salinity concentrations of all SNWR waters, and it is observed to influence the nearby canals. The increase in salinity in the Rio Grande appears to be caused by SA springs and its evaporative pools. Major ion, stable isotope, and trace element analyses suggest that SA is chemically similar to the RSB waters and that the SA brine pool has evolved through evaporative concentration. RSB has been established as having deeply-derived fluid sources based on He isotopic data. We conclude that rift-bounding and intra-rift basement-penetrating faults can provide "fast paths" for the ascent of saline fluids. These endogenic waters are potentially influenced by relatively small volumes of upwelling fluids through granitic basement (with associated increases in F, Li and Ba) and the Socorro Magma Body (excess CO_2). Within the SA region there are numerous springs that are all potential fault-controlled endogenic fluid sources. Salinity sources that contribute to the salinization of the Rio Grande through fault conduits at San Acacia degrade the water quality of the Rio Grande and its aquifers, posing a hazard to downstream users.

A POPULATION OF NONMARINE BIVALVES (UNIONOIDA: ANTHRACOSIIDAE) FROM THE LOWER PERMIAN (WOLFCAMPIAN) SANGRE DE CRISTO FORMATION IN THE ROWE-MORA BASIN, NORTH-CENTRAL NEW MEXICO,
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We describe a rich deposit of thin-shelled, freshwater bivalves that constitute the first documented occurrence of these clams in the Pennsylvanian-Permian Sangre de Cristo Formation of the Rowe-Mora basin. The clams are from laminar, greenish-grey, micaceous shale beds of lacustrine origin at NMMNH locality 7889 near Glorieta Pass (T15N, R11E, Santa Fe Co.) in the upper part of the Sangre de Cristo Formation. These strata are of probable Early Permian (Wolfcampian) age. The clams are preserved as external and (rarely) internal casts that typically lie on the bedding planes with the articulated valves closed, although some show the paired valves wide open (~180^{o}) and the hinge intact. Plant debris, including partial walchian fronds and cordaitalean material, and poorly-preserved conchostricans are common in the clam-bearing stratum.

The clams are equivalved, inequilateral, and elongate oval in shape. The hinges are straight and adductor muscle scars are absent or not preserved. Length ranges from ~ 8 to 26 mm. The beaks are anteriorly inclined, and the umbones are slightly inflated and located at ~ 0.25 of length from the anterior end. Ornamentation consists only of concentric growth ridges. Two variants, one with a rounded posterior end, and the other more blunt, may represent sexual dimorphs. Average height-to-length ratio (= 0.35), allometric growth constant, and overall morphology including the two variants are very similar to the Permian anthracosiid, *Palaeanodonta,* recently reported from the El Cobre Canyon Formation of the Cutler Group in the Chama basin. The Cutler Group record is Wolfcampian and in a different Paleozoic basin from the Rowe-Mora basin record, implying possible riverine connections between the two basins.

UPPER CRETACEOUS (TURONIAN) AMMONITES FROM THE CARLILE AND JUANA LOPEZ MEMBERS OF THE MANCOS SHALE, EASTERN SIDE OF MESA PRIETA, SANDOVAL COUNTY, NEW MEXICO, *SEALEY, P.L.*, and *LUCAS, S.G.*, New Mexico Museum of Natural History, 1801 Mountain Road NW, Albuquerque, New Mexico 87104

The zones of *Collignoniceras woollgari, Prionocyclus hyatti*, *Prionocyclus macombi*, *Prionocyclus wyomingensis* and *Prionocyclus novimexicanus* are present in the Carlile and Juana Lopez members of the Mancos Shale on the eastern side of Mesa Prieta, Sandoval County, New Mexico. Here, (T16N, R1W) the Greenhorn interval (with abundant *Pyconodonte newberryi*) is ~ 7 m thick and is overlain by the ~ 60 m thick Carlile Member (locally, no Semilla Sandstone is present) capped by the ~ 36 m thick Juana Lopez Member. The ammonite fauna from the Carlile Member includes *Collignoniceras woollgari*, *Tragodesmoceras carlilense*, *Romaniceras mexicanum*, *Herrickiceras costatum*, *Spathites puercoensis*, *Prionocyclus hyatti*, *Placenticeras pseudoplacenta*, and *Coilopoceras springeri* in two assemblage zones, lower (woolgari) and upper (hyatti) separated by ~25 m of section. The ammonite fauna from the Juana Lopez Member includes *Prionocyclus macombi*, *Coilopoceras colleti*, *Placenticeras* sp., *Coilopoceras inflatum*, *Prionocyclus wyomingensis*, *Scaphites ferronensis*, *Prionocyclus novimexicanus* and *Scaphites whitfieldi*, from throughout the member.

The *Collignoniceras woollgari* Zone also occurs at other places in New Mexico including the lower part of the Tres Hermanos Sandstone Member and upper part of the Rio Salado Member at Carthage and the lower Carlile Member at Galisteo Dam. The *Prionocyclus hyatti* Zone also occurs at other places in New Mexico, including the Carlile Member at Galisteo Dam and the Semilla Sandstone and Carlile members at La Ventana. The *Prionocyclus macombi* Zone also occurs at many other places in New Mexico, including the type and reference sections of the Juana Lopez at Galisteo Dam and La Ventana, respectively. The *Prionocyclus wyomingensis* Zone also occurs in the Juana Lopez Member at the type and reference sections, in the D-Cross Member at Cebollita Mesa, and in the D-Cross Member at D-Cross Mountain. The zone of *Prionocyclus novimexicanus* also occurs at various New Mexico locations, especially in the D-Cross and Juana Lopez members of the Mancos Shale. The *C. woollgari* Zone is of early middle Turonian age. The *P. hyatti* and *P. macombi* zones are of middle Turonian age, the *P. wyomingensis* Zone is of late-middle Turonian age, and the *P. novimexicanus* Zone is of late Turonian age.

CRANIAL ANATOMY AND TAXONOMY OF *SPHENACODON FEROX* (EUPELYCOSAURIA: SPHENACODONTIDAE) FROM THE LATE PENNSYLVANIAN-EARLY PERMIAN OF NEW MEXICO, *SPIELMANN, J.A., RHINEHART, L.F.*, and *LUCAS, S.G.*, New Mexico Museum of Natural History and Science, 1801 Mountain Rd. NW, Albuquerque, New Mexico 87104; *BERMAN, D.S.,* and *HENRICI, A.C.*, Section of Vertebrate Paleontology, Carnegie Museum of Natural History, 4400 Forbes Ave., Pittsburgh, Pennsylvania 15213; and *HARRIS, S.K.*, New Mexico Museum of Natural History and Science, 1801 Mountain Rd. NW, Albuquerque, New Mexico 87104

Sphenacodon is a pelycosaurian-grade synapsid, best known from the Lower Permian of Rio Arriba County, northern New Mexico. Of the two species (*S. ferox* and *S. ferocior)*, *S. ferox* is known from comparatively little skull material, and the skulls historically assigned to the taxon are heavily reconstructed and composed of few actual cranial elements. In contrast, *S. ferocior* is known from numerous nearly complete skulls that have been extensively illustrated and described in the literature. Here, we report on a new, nearly complete skull of *S. ferox* collected from the eastern wall of the Cañon del Cobre in a *Sphenacodon*-dominated bonebed (NMMNH locality 5379). Lithologically, the quarry is in a finely laminated, dark reddish brown, immature arkosic sandstone with pale, greenish-yellow banding at ~10 cm intervals and is within the upper vertebrate assemblage zone of the Cañon del Cobre (Seymouran land vertebrate faunachron). This new skull demonstrates numerous cranial differences between *S. ferox* and *S. ferocior* including: overall skull size; number of premaxillary teeth; number of precanine maxillary teeth; shape of the ventral maxillary margin; shape of the maxillary step; development of the dorsal lamina of the maxilla; thickness of the orbital process of the frontal; shape of the anteroventral corner of the temporal fenestra; shape of the squamosal-jugal suture; shape of the parietals; and extent of the dental field on the palatal ramus of the pterygoid. *S. ferox* has a temporal range from the Late Pennsylvanian (late Virigilian: Coyotean lvf) through the Early Permian (late Wolfcampian: Seymouran lvf), whereas *S. ferocior* is restricted to the Coyotean lvf, but does span the Pennsylvanian-Permian boundary.

VERTEBRATE ICHNOLOGY OF THE UPPER TRIASSIC (APACHEAN) REDONDA FORMATION, EAST-CENTRAL NEW MEXICO, *SPIELMANN, J.A.*, and *LUCAS, S.G.*, New Mexico Museum of Natural History and Science, 1801 Mountain Rd. NW, Albuquerque, New Mexico, 87104; *KLEIN, H.,* Rübezahlstr. 1, D-92318 Neumarkt, Germany; and *LERNER, A.J.*, New Mexico Museum of Natural History and Science, 1801 Mountain Rd. NW, Albuquerque, New Mexico, 87104

The Upper Triassic Redonda Formation, the uppermost part of the Chinle Group in east-central New Mexico, yields extensive vertebrate ichnofossil assemblages that were first discovered in the 1930s. As much as 92 m thick, the Redonda Formation in its outcrop belt along the northwestern edge of the Llano Estacado (Guadalupe and Quay counties, New Mexico) can be divided into five members (ascending order): Quay (a replacement name for Red Peak), San Jon Creek, Duke Ranch, Wallace Ranch and Montoya Point (laterally equivalent to the Duke Ranch and Wallace Ranch members). Redonda deposition took place in a palustrine system that comprised a mosaic of lakes, lake margins, fluvial channels, floodplains and stable interfluves. Most of the Redonda ichnofossil assemblages are from lake margin facies abundantly preserved in the San Jon Creek Member. Presumed lungfish burrows from the Redonda Formation pertain to *Redondarefugium abercrombieorum* and are vertical to obliquely oriented, slightly helical, unlined burrows with a round cross section, little ornamentation of the burrow walls and a flask-shaped terminus. Redonda Formation tetrapod footprints are assigned to: *Brachychirotherium parvum*, *Brasilichnium elusivum*, *Characichnos* ichnosp., *Evazoum* ichnosp., *Grallator cursorius*, *Gwyneddichnium* (= "*Apachepus*") *cottonorum* and *Rhynchosauroides* ichnosp. Redonda tetrapod footprints represent the *Brontopodus* ichnofacies, more specifically the *Evazoum* ichnocoenosis. The track assemblages of the Chinle represent a global Late Triassic footprint record dominated by the tracks of crurotarsans, dinosaurs and sphenodonts.

THE INFLUENCE OF ANTECEDENT SNOWPACK, AEROSOLS AND ENSO ON THE NORTH AMERICAN MONSOON, *STURGIS, J.*, and *GUTZLER, D.S.*, Department of Earth & Planetary Sciences, University of New Mexico, Albuquerque, New Mexico 87131

The factors influencing the North American monsoon and New Mexico's summer precipitation are investigated using statistical relationships. Antecedent conditions including snowpack, spring wildfires and other aerosol forcing, and sea surface temperature in the Niño 3.4 region of the equatorial Pacific, have each been linked to the onset of the monsoon or the total precipitation during the monsoon season. This study aims to synthesize several previous studies by considering all of these antecedent variables, in order to produce a multivariate empirical predictive scheme.

High antecedent snowpack and wildfire/aerosol forcing are negatively correlated with onset and precipitation, while the correlation between SST and the monsoon is more complex. These variables show different relationships with the monsoon in two periods, 1961-1990 and 1991-2006; the causes of this shift are under investigation.

NEW PALYNOLOGICAL DATA FROM CRETACEOUS STRATA IN THE SAN JUAN BASIN, NEW MEXICO, DO NOT INDICATE A PALEOCENE AGE FOR DINOSAUR FOSSILS, *SULLIVAN, R.M.*, Section of Paleontology and Geology, The State Museum of Pennsylvania, 300 North Street, Harrisburg, Pennsylvania 17120; *BRAMAN, D.R.*, Royal Tyrrell Museum of Palaeontology, P.O. Box 7500, Drumheller, Alberta T0J 0Y0, Canada; *JASINSKI, S.E.*, Section of Paleontology and Geology, The State Museum of Pennsylvania, 300 North Street, Harrisburg, Pennsylvania 17120; *LUCAS, S.G.*, New Mexico Museum of Natural History and Science, 1801 Mountain Rd. NW, Albuquerque, New Mexico 87104

Claims of Paleocene dinosaur fossils in the San Juan Basin have been largely based on palynostratigraphy---namely, that in situ Paleocene-age palynomorphs are found stratigraphically below in situ dinosaur fossils. One key locality is Barrel Springs in the west-central San Juan Basin (sec. 17, T24N, R11W), where a carbonaceous shale bed at the top of the De-na-zin Member of the Kirtland Formation supposedly yielded Paleocene-age palynomorphs below the in situ dinosaur fossils in the overlying Naashoibito Member of the Ojo Alamo Formation. We have repeatedly sampled this carbonaceous shale bed, most recently in 2009, and it yields only Cretaceous palynomorphs. Thus, the presence of *Tschudypollis thalmanni* and *Equisetosporites multipartitus* at this locality indicates a Late Cretaceous age, probably Maastrichtian. In 2009, we also sampled this carbonaceous shale bed at the top of the Kirtland Formation at Willow Wash, ~ 6 km to the northwest, and here it also yields a Cretaceous palynomorph assemblage. The presence of abundant *Tschudypollis thalmanni* and *T. retusus* at this second locality also suggests a Late Cretaceous age for the sample, probably Maastrichtian. We therefore consider the report of Paleocene palynomorphs from this bed at Barrel Spring a non-repeatable result, so it is not reliable for age assignment. Palynostratigraphy provides no support for assigning a Paleocene age to dinosaur fossils in the west-central San Juan Basin, New Mexico.

INSIGHTS INTO THE RELATIONSHIP BETWEEN CONTINENTAL WEATHERING AND HIGH-FREQUENCY (10^4-10^5 YR) GLACIO-EUSTASY FROM CYCLOSTRATIGRAPHY, $\Delta^{18}O$, AND TRENDS IN ε_{ND}, *THEILING, B.*, *ELRICK, M.*, *ASMEROM, Y.*, and *POLYAK, V.*, Department of Earth & Planetary Sciences, University of New Mexico, Albuquerque, New Mexico 87131

Nd-isotope trends (reported as ε_{Nd}) from modern and ancient marine deposits have been utilized to document patterns and changes in marine circulation and continental weathering. When combined with $\delta^{18}O$ trends from marine deposits, we hypothesize that ε_{Nd} will provide new insights into local climate fluctuations during high-frequency (10^4-10^5 yr) glacial-interglacial cycles. Here we present whole-rock ε_{Nd}, conodont apatite $\delta^{18}O$, and cyclostratigraphy from the Middle Pennsylvanian Gray Mesa Formation of central New Mexico to evaluate potential relationships between glacio-eustasy and continental weathering rates during an icehouse climate.

Samples were collected from seven consecutive high-frequency cycles (2-4 m thick). Upward-shallowing facies trends within the cycles are characterized by thin-bedded skeletal mudstone/wackestone (deep subtidal facies), overlain by massive skeletal wackestone/packstone (shallow subtidal facies), and are commonly capped by calcretes, regolith breccias, and/or $\delta^{13}C$ values indicative of prolonged subaerial exposure during sea-level fall/lowstand. These asymmetric facies patterns suggest abrupt transgression above the underlying cycle cap followed by gradual regression through most of cycle development.

$\delta^{18}O$ trends for 3 of the 4 sampled cycles record 0.8 ‰ to 1.2 ‰ up-cycle increases, which is consistent with a glacio-euastic origin for cycle formation. ε_{Nd} trends from 6 of the 7 sampled cycles are characterized by mid-cycle minimum ε_{Nd} values (before maximum regression). We interpret that maximum influx of local fluvial sediment (lowest ε_{Nd} values) occurred during interglacial intervals when the local paleotropical climate was wettest, and minimum fluvial influx (maximum ε_{Nd} values) occurred during glacial intervals when the climate was the driest. This interpretation is supported by Pleistocene climate records, which show that during glacial intervals, the tropics were drier, whereas during interglacial intervals, the tropics were wetter. These preliminary results suggest that local paleotropical climate changes and associated continental weathering were influenced by the same 10^4-10^5 yr mechanisms that drove Middle Pennsylvanian glacio-eustasy.

WATER CHEMISTRY TRENDS FROM WELLS AND SPRINGS IN THE SOUTHERN SACRAMENTO MOUNTAINS, NEW MEXICO, *TIMMONS, S.S.*, stacyt@gis.nmt.edu, and *NEWTON, B.T.*, New Mexico Bureau of Geology and Mineral Resources, New Mexico Institute of Mining and Technology, 801 Leroy Place, Socorro, New Mexico 87801; and *PARTEY, F.K.*, AMEC Earth and Environmental, PMB Airport Post office, East Legon, ACCRA, Ghana

As part of the southern Sacramento Mountains Hydrogeology Study, funded by the Otero Soil and Water Conservation District, the New Mexico Bureau of Geology and Mineral Resources has sampled 42 springs and 77 wells for ion chemistry and trace metals, as well as other constituents. Overall, spring and well samples indicate that ground water is dominated by calcium and magnesium as the cations and bicarbonate and sulfate as the main anions. These results support that carbonate dissolution is the dominant chemical process influencing the water chemistry.

Springs, located mostly within the high mountains region of the study area, are typically cool waters (on average 10°C) and are dominantly calcium-bicarbonate or calcium-magnesium bicarbonate water types. Springs found in the northern regions of the study area have higher TDS and concentrations of sulfate, chloride, strontium, sodium, magnesium, silica.

Well water samples, which were collected from sites over a larger region, have higher specific conductance and higher ion concentrations, in general, compared to springs. Also, well water temperatures are warmer than springs at an average of 15.4°C. About 32% of the well water types are calcium-bicarbonate or calcium-magnesium bicarbonate (similar to springs), but also have slightly more “evolved” water types, with about 65% calcium-magnesium bicarbonate-sulfate, or sulfate-bicarbonate water types. Similar to springs, well water samples show increases in ion concentrations towards the north, but the dominant increases are found towards the east.

The trends of our water chemistry, with some ground water ages, suggest regional ground water flow paths exist, despite multiple perched aquifers in the highly heterogeneous Yeso Formation. Ground water is recharged in the high mountains, and flows to the east and north. Most springs and wells with fairly young, fresh meteoric waters are found in the high mountains area, while wells further east along the Pecos Slope have older, more chemically evolved signatures due to longer water-rock interactions. These chemical changes in the ground water may also be affected by lithologic changes within the Yeso and San Andres Formations.

MODELING PYRITE AND FLUORIDE CONCENTRATION IN THE GOATHILL NORTH ROCK PILE, QUESTA MINE, NEW MEXICO, *WILLIAMS, S.F.*, swilliams@gis.nmt.edu, NM Bureau of Mines & Mineral Resources, New Mexico Institute of Mining & Technology, 801 Leroy Place, Socorro, New Mexico 87801.

The New Mexico Bureau of Geology and Mineral Resources recently took part in an elaborate study called the Questa Rock Pile Weathering and Stability Project. The purpose of this project was to determine how and to what extent weathering affects the gravitational stability of the Questa mine rock piles over time periods on the order of 100s to 1000s of years. During the period of open pit mining (1969-1982) at the Questa mine, several million tons of overburden rock was removed and deposited into rock piles on mountain slopes and into valleys. Since the emplacement of these rock piles, several minor slumps have occurred as well as a foundation failure at Goathill North (GHN) rock pile. This slide was halted and GHN made stable by removing material from the top and relocating it to the bottom forming a buttress. The regraded GHN provided a rare opportunity to examine, sample, and develop a conceptual model of the undisturbed interior of a large mine rock pile in situ. During this process, several hundred parameters were measured, tested, and observed. Specifically, this poster describes the techniques used to model the distribution of pyrite and fluoride concentration within the rock pile.

Modeling was performed using the Geostatistical Analyst Extension in ESRI's ArcGIS (version 9.3.1) software. The models used were: Inverse Distance Weighting, Global Polynomial Interpolation, Local Polynomial Interpolation, and Radial Basis Functions. It was found that both Inverse Distance Weighting and Radial Basis Functions produced realistic models while Global Polynomial Interpolation and Local Polynomial Interpolation did not produce realistic models. Ultimately, however, the very nature of the pyrite and fluoride distribution within the rock pile makes any model unrealistic. In the 30 years since the rock pile's emplacement, not enough weathering had occurred to preferentially relocate and concentrate pyrite or fluoride. In the rock pile, pyrite and fluoride are still randomly distributed and dependent on where loads of mined rock were dumped, rather than distributed by some physical process that can be effectively modeled.

NEW MEXICO'S MOST PROLIFIC UPPER CRETACEOUS SHARK ASSEMBLAGE: HOSTA TONGUE OF THE POINT LOOKOUT SANDSTONE, BERNALILLO COUNTY, NEW MEXICO, *WRIGHT*, *K*., *BOURDON*, *J*., *LUCAS*, *S*., and *PENCE*, *R*., New Mexico Museum of Natural History, 1801 Mountain Road NW, Albuquerque, New Mexico 87104

We present a follow-up to a preliminary analysis published in 1989 of a selachian fossil assemblage in the Upper Cretaceous Hosta Tongue of the Point Lookout Sandstone along the Rio Puerco drainage in Bernalillo County. The Point Lookout Sandstone is the lowest stratigraphic unit of the Mesa Verde Group, and the lower Santonian Hosta Tongue is the lowest horizon of the Point Lookout Sandstone. An extremely prolific lens of selachian teeth and other fossils is located at NMMNH locality 297. The fossiliferous lens is about 6 cm thick. Approximately 80 kg of in-situ material was processed and screened in a sieve stack down to 0.5 mm mesh. This process yielded about 5000 selachian teeth that represent members of at least six orders, with at least 30 species represented, including several previously undescribed genera and species and others new to the New Mexican fossil record. The teeth show little transport wear. Also present in great numbers are small calcified selachian centra and small to very small teleost teeth and vertebrae. The assemblage is dominated by *Scapanorhynchus*, *Pseudohypolophus*, and *Ptychotrygon*. This dominance of small Lamniformes and durophagous species suggests a shallow water environment and a terrestrial component suggests a deltaic condition. This terrestrial component includes teeth of crocodylians, hadrosaurs and dromaeosaurs and bits of wood and plant seeds. Also present in the fauna are teeth and scales of gars and shell fragments of softshell turtles (Trionychidae). Some of the other genera represented are: *Hybodus*, *Lonchidion*, *Ptychodus*, *Squatina*, *Cederstroemia*, *Cantioscyllium*, *Chiloscyllium*, ?*Odontaspis*, *Carcharias*, *Squalicorax*, *Cretalamna*, *Cretoxyrhina*, *Protolamna*, *Ischyrhiza*, *Sclerorhynchus*, *Texatrygon*, *Rhinobatos*, *Protoplatyrhina*, and *Myledaphus*.

EFFECTS OF LATERAL AND VERTICAL HETEROGENEITY IN THE YESO FORMATION ON THE REGIONAL HYDROGEOLOGY IN THE SACRAMENTO MOUNTAINS, NM, *ZEIGLER, K.E.*, zeiglergeo@gmail.com, ZGC, Albuquerque, New Mexico 87123; *NEWTON, B.T.*, and *TIMMONS, S.S.*, New Mexico Bureau of Geology and Mineral Resources, New Mexico Institute of Mining & Technology, 801 Leroy Place, Socorro, New Mexico 87801

During the spring of 2009, four shallow wells with total depths from 80 to 420 feet were drilled on private property along James Canyon, located approximately 6 miles east of Cloudcroft, in southeastern New Mexico. Three of these wells were drilled as monitoring wells as part of the Sacramento Mountains Watershed Study being done by the New Mexico Bureau of Geology and Mineral Resources. All 4 wells were located within 2.5 miles of each other. Water level elevations in the monitoring wells range from 7102 to 7916 feet above sea level, with the shallowest depths to water at higher elevations and deeper water at lower elevations. During drilling, well cuttings were collected at ten-foot intervals and stratigraphic columns at each well site constructed, in order to attempt local correlations between wells. This well series demonstrates the regional and local heterogeneity of the Yeso Formation, both laterally and vertically. No direct bed-to-bed correlations could be made among any of the four wells. In fact, the four wells do not exhibit the same lithology, even where they overlap one another, despite their relative geographic proximity. However, tentative correlations between the wells and a deep well drilled in Cloudcroft in 2006 l can be made using transgressive/regressive cycles identified in the stratigraphic columns. These tentative correlations suggest at least six transgressive events occurred in southeastern New Mexico during the Permian.

The extreme lateral heterogeneity observed in the Yeso Formation is apparently a result of local sea level changes during the time of deposition, in addition to dissolution collapse due to hydration and dehydration of salts and formation of karst features in the upper Yeso Formation. The effects of this lithologic heterogeneity combined with regional fracture systems on the local and regional hydrogeology is apparent by the high variability of water level elevations observed in three of the four wells. It is likely that the four wells are tapping four different saturated water-bearing zones. The relatively shallow water bearing zones found at the higher elevation wells probably represent different perched aquifer systems at different stratigraphic levels. The deeper groundwater encountered in the lowest elevation well may represent a more regional aquifer system.

NATIVE AMERICAN LITHIC PROCUREMENT PATTERNS AND SITES IN THE BOOT HEEL OF SOUTHWESTERN NEW MEXICO, *ZEIGLER, K.E.*, zeiglergeo@gmail.com, ZGC, Albuquerque, NM, 87123; *HUGHES, C.*, *KUROTA, A.,* and *HOGAN, P.*, Office of Contract Archeology, MSCO7 4230, 1717 Lomas NE, 1 University of New Mexico, Albuquerque, NM 87131

Multidisciplinary field projects can be very useful to a more fundamental understanding of the world around us, though these projects are not as common as they should be. In particular, the combination of archeology and geology combines our understanding of human behavior and human use of the landscape with an intimate knowledge of geologic processes and the materials available for human use in order to gain a broader understanding of human-Earth interaction. Here we present data from a cross-disciplinary project that uses a common dataset, archeological artifacts, to explore the anthropological and geologic implications of useage patterns. Archeological excavations and surveys conducted by the Office of Contract Archeology in 2007 along the route of the proposed international border fence reveal patterns of use of geologic materials by Archaic, Formative and Protohistoric Native Americans in the Boot Heel of southwestern New Mexico. Thousands of artifacts were recorded in multiple sites from Guadalupe Pass in the southern Peloncillo Mountains to the Carrizalillo Hills west of Columbus. We identified the lithologies of artifacts, ranging from projectile points to groundstones, and then constructed material movement maps based on either known procurement sites ("quarries") or outcrops identified as the closest source to a given site for each lithology. Not unexpectedly, the majority of the rock types utilized by native peoples are local siliceous volcanic materials. However, several artifacts constructed from obsidian were transported into the region from northern Mexico and eastern Arizona, indicating long-distance travel and/or trade routes. We also examine useage pattern difference between Archaic, Formative and Protohistoric sites. Additionally, a dramatic change in distribution of sources for geologic materials occurs between one pre-Spanish site and one post-Spanish site that are adjacent to one another.