Abstracts

New Mexico Geology recognizes the important research of students working in post-graduate M.S. and Ph.D. programs. The following abstracts are from recently completed M.S. theses and Ph.D. dissertations that pertain to the geology of New Mexico and neighboring states.

New Mexico Institute of Mining and Technology

INVESTIGATION OF DIRECT AND INDIRECT HYDRAULIC PROPERTY LABORATORY CHARACTERIZATION METHODS FOR HETEROGENEOUS ALLUVIAL DEPOSITS: APPLICATION TO THE SANDIA-TECH VADOSE ZONE (STVZ) INFILTRATION TEST SITE, by Kristine E. Baker, 2001, M.S. thesis, Department of Earth and Environmental Science, New Mexico Institute of Mining and Technology, Socorro, NM 87801, 475 pp.

The need to predict water flow and solute transport at contaminated waste storage facilities has shifted the focus of unsaturated flow research from near surface soils to deep vadose zone alluvium deposits. The primary objective of this research was to characterize the hydraulic properties of deep vadose zone deposits collected from a vadose zone research facility in Socorro, New Mexico, using both direct and indirect laboratory methods. Samples collected from the site were analyzed for moisture retention, electrical resistivity, hydraulic conductivity, porosity, and particle-size distributions. The measured results were then compared to properties reported for similar sandy soils and alluvial sands to determine the need to characterize heterogeneous vadose zones independently. Correlations between measured parameters were examined to minimize the number of measurements required in site characterization. The Haverkamp and Parlange (1986) parameter estimation model and a similar estimation model developed as part of this research (to predict the van Genuchten parameters) were used to estimate moisture retention parameters for samples collected at the site.

Direct laboratory measurements of moisture retention for the site deposits showed curve fitting parameters that vary from values reported for sandy soils of similar texture; however, they appeared to be similar to values reported for sandy alluvial deposits. This suggests that values reported for soils in many soil databases should not be used to predict flow and transport in deep, alluvial vadose zone environments. In addition, the STVZ deposits all exhibited a non-unique relationship between moisture content and matric potential (known as hysteresis), whereas the relationship between measurements of electrical conductivity and moisture content did not appear to be hysteretic. It is possible that a porous medium may not exhibit hysteresis in electrical resistivity measurements even if hysteresis is observed in moisture retention measurements because the potential energy state of a porous medium is determined by conditions at the air-water-solid interfaces, and the nature of surface films rather than by the quantity of water present in pores. On the other hand, electrical conductivity is a function of the pore scale fluid distribution within the medium. This research suggests that the non-unique relationship between moisture content and matric potential is less appealing than the relationship between electrical resistivity and moisture content for monitoring changes in moisture content over intermittent periods of wetting/draining conditions.

Both the parameter estimation models evaluated in this study appeared to produce estimates of moisture retention properties comparable to results obtained using direct laboratory methods; however, both models require individual calibration for narrow distributions of particle sizes and porosities. Although the separate calibrations may be cumbersome, this research suggests that property estimation models can be used to reduce the time intensity of direct laboratory measurements, thus increasing the number of samples analyzed for site characterization. Model predictions could be improved by reducing sample disturbance during collection and analysis and increasing sample sizes for laboratory analysis. Direct measurements of air entry pressure, porosity, and residual moisture content would also improve the model predictions.

OCCURRENCE AND SOURCES OF ARSENIC IN GROUND WATER OF THE MIDDLE RIO GRANDE BASIN, CENTRAL NEW MEXICO, by Laura M. Bexfield, 2001, M.S. thesis, Department of Earth and Environmental Science, New Mexico Institute of Mining and Technology, Socorro, NM 87801, 191 pp.

An understanding of the occurrence and sources of arsenic in ground water of the middle Rio Grande basin (MRGB), central New Mexico, is essential to the establishment of drinking-water supplies that will consistently meet the new standard of 10 µg/l established by the U.S. Environmental Protection Agency for arsenic in drinking water. New chemical data from 288 ground-water sites, supplemented by historical data from the U.S. Geological Survey and the city of Albuquerque, show that arsenic concentrations in ground water exceed 10 µg/l across broad areas of the basin. The data indicate that arsenic concentrations in the MRGB are determined primarily by the source and geochemical origin of ground water rather than by chemical processes within the basin. One primary source of arsenic to the basin is related to volcanic activity in the Jemez Mountains to the north, where dilute recharge water likely flows through rocks that have been altered by contact with geothermal fluids. The other primary source is mineralized water of deep origin that mixes with shallower ground water in several locations around the MRGB, particularly along major structural features. Values of pH that exceed 8.5, where present, appear to cause desorption of arsenic from metal oxides. Analysis of normative salt assemblages calculated using the computer program SNORM (Bodine and Jones, 1986) indicates that MRGB ground waters associated with carbonate-rock dissolution and weathering of calcic lithologies tend to have smaller arsenic concentrations than ground waters associated with hydrothermal systems or with the weathering of sodium-dominated siliceous rocks.

LABORATORY INVESTIGATIONS AND ANALYTICAL AND NUMERICAL MODELING OF THE TRANSPORT OF DISSOLVED SOLUTES THROUGH SATURATED FRACTURED ROCK, by Timothy James Callahan, 2001, Ph.D. dissertation, Department of Earth and Environmental Science, New Mexico Institute of Mining and Technology, Socorro, NM 87801, 153 pp.

The objective of this research was to determine the applicability of reactive tracer data obtained from laboratory tests to larger-scale field settings. Laboratory tracer tests were used to quantify transport properties in fractured volcanic ash flow tuff from southern Nevada. In a series of experiments, a pulse containing several ionic tracers was injected into four tuff cores, each containing one induced fracture oriented along the main axis. Multiple tests were also conducted at different flow velocities. Transport data from nonreactive tracers of different diffusivity allowed the separation of the effects of hydrodynamic dispersion within the fracture and molecular diffusion between flowing and non-flowing water within the systems, which was presumed to be in the fracture and bulk porous matrix, respectively. Reactive tracers were also included to estimate the sorption capacity of the tuffs.

The experiments verified the importance of fracture/matrix and solute/solid interactions in the fractured tuffs. Using artificial tracers of different physical and chemical properties in the same test provided unique interpretations of the tests and minimized uncertainty in transport parameter estimates. Compared to separate field tests in the rock types, the laboratory experiments tended to over estimate the degree of diffusive mass transfer and under estimate sorption capacity due to the small scale and high tracer concentrations, respectively. The first result suggests that geometry differences between lab apparatuses and field systems precluded the direct extension of laboratory-derived transport parameters to field scales. For example, smaller-scale processes such as diffusion within the stagnant water in the fractures (free-water diffusion), caused by fracture aperture variability, were more important at small time scales. Because free water diffusion coefficients are larger than matrix diffusion coefficients, this led to an over estimation of the amount of diffusive mass transfer. Furthermore, laboratory diffusion cell tests provided independent estimates of matrix diffusion coefficients for the tracers, and these values were similar to those estimated for the same tracers in the field tests. Thus, the value of the diffusion coefficients in the larger-scale field tests appeared to approach their asymptotic "true" values because of the larger volume of porous rock accessed during tracer testing.

The sorption capacity of the solid material was under estimated in both the laboratory and field tracer experiments. A fraction of the ion-exchanging tracer (lithium) moved through the system unretarded because the ion exchange sites on the solid phase were overwhelmed by the tracer. This happened more so in the laboratory tests due to the smaller amount of dilution in the system. These results clearly indicate that by injecting high-concentration tracers during cross-well tests, the tracer data can indicate sorption parameters smaller than those determined under lower-concentration conditions.

These results indicate that one should be cautious when applying laboratory-derived tracer

data to field settings. The use of multiple tracer experiments conducted over a wide range of time scales and injection concentrations will help avoid ambiguity of the derived transport parameters.

TRANSPORT OF ANTHROPOGENIC AND NATURAL SOLUTES NEAR A PREHISTORIC NATIVE AMERICAN PUEBLO, by Daniel C. Dolmar, 2001, M.S. thesis, Department of Earth and Environmental Science, New Mexico Institute of Mining and Technology, Socorro, NM 87801, 183 pp.

Two solute tracers of anthropogenic origin were identified near a prehistoric Native American pueblo in central New Mexico. These anthropogenic tracers, the chloride:bromide ratio (Cl^-:Br^-) and nitrate (NO_3^-), were present in two boreholes where thick, intact midden deposit was present but absent in five other more pristine boreholes. The Cl:Br signal has traveled 140 ± 30 cm, and the nitrate peak has traveled 220 ± 40 cm in the 625 ± 70 yrs since the time the midden was deposited.

Unconfined water was not found in any of the boreholes drilled at the site. Several lines of evidence indicate that there is upward flow from a leaky confined aquifer encountered at 800–2,100 cm below ground surface. A conceptual model of water flow and solute transport at the pueblo site was formed that included: (1) upward flow from the leaky confined aquifer to the root zone; (2) the Cl:Br ratio and NO_3^- peaks are assumed to be man-made; and (3) precipitation and evapotranspiration, which were hypothesized to be sufficient to explain the anthopogenic solute positions.

The anthropogenic solute signals were modeled with the HYDRUS-1D unsaturated water and solute transport code. Modeling results were compared to the data gathered at the field site, and it was demonstrated that the relatively simple conceptual model could be calibrated with the data from the field site. Model results indicate that the majority of the transport of the anthropogenic solutes took place very early in the time since midden deposition, and that the anthropogenic solutes are essentially frozen in place, pending some unusually high degree of wetness that would push them farther down into the profile. In the numerical model, solute transport events take place in the winter when transpiration is zero and potential evaporation is low, and are due to an accumulation of several storm events. The HYDRUS simulations predict that the anthropogenic solutes do not move below the root zone, and therefore also predict that no recharge from precipitation is occurring at the site.

The simulated solute peak position was used as a performance measure in a sensitivity analysis of the HYDRUS model. The peak position is sensitive to the unsaturated hydraulic conductivity in the upper 120 cm of the profile, to the particulars of the top boundary condition, and to the maximum rooting depth. By contrast, the peak position is relatively insensitive to the wilting point.

The upward flow process below the root zone was also modeled with HYDRUS. This work predicts that the environmental solute peaks remain at the bottom of the root zone at ~400 cm bgs, and are held there by the upward flow coming from the underlying leaky confined aquifer and the subsequent removal of this water flow by the plant roots.

EVIDENCE OF AN OCEANIC PLATEAU ORIGIN AND A DEEP, DEPLETED MANTLE SOURCE FOR THE IRON KING VOLCANICS, A 1.75-GA ACCRETED TERRANE IN CENTRAL ARIZONA, by Bonnie A. Frey, 2002, M.S. thesis, Department of Earth and Environmental Science, New Mexico Institute of Mining and Technology, Socorro, NM 87801, 151 pp.

The Iron King Volcanics in central Arizona contains lithologies (pillow basalts, hyaloclastites and hydrothermal cherts) common to the northeast-striking oceanic terranes that were accreted to the North American continent during the Paleoproterozoic. Contrary to early interpretations that these terranes are island arc sequences, the Iron King Volcanics has a basalt component that does not carry trace element signatures characteristic of island arc basalts but shows evidence for an oceanic plateau origin. As such, this component is referred to as the plume component. Evidence includes a submarine, basalt-dominated lithologic sequence with flat REE patterns and incompatible trace element patterns that do not show Ta–Nb anomalies. A comparison of incompatible element ratios (Th/Ta, La/Yb, Nb/Y, Zr/Y, Sm/Yb, and Nb/Zr) in the Iron King Volcanics to volcanics from other tectonic settings supports this hypothesis. A second component of the Iron King Volcanics has lithologic and geochemical affinities to an island arc sequence, based on a volcanic sequence dominated by felsic and intermediate lithologies and the Ta–Nb depletion observed relative to other incompatible elements.

The Iron King plume volcanics contain two geochemical groups: an enriched group and a nonenriched group. These groups may have formed from different degrees of melting in different regions of the plume head. The enriched group was probably produced by small degrees of melting in a relatively cool outer section of the plume head, and the nonenriched group was produced closer to the plume's hot tail. The relationship of Nb/Y to Zr/Y in the Iron King plume-derived basalts suggests a mantle source with mixed depleted and enriched end members. The depleted end member was probably a deep rather than a shallow source. The mantle plume may have entrained enriched mantle material as it ascended. Like many other oceanic plateaus, the Iron King magmas developed at depths within the garnet stability field (> 75 km), supported by modeling that relates CaO/Al_2O_3 ratios to pressure.

The plume component is interpreted to be an upper section of an oceanic plateau sliced off during obduction. Several models are suggested for the association of the plume and arc components. An acceptable model should take into consideration the absence of rock types common to deeper regions of an oceanic plateau and deformational features common to both the plume and arc components. Two models involve arc formation along the margin of an oceanic plateau: (1) The oceanic plateau collides with the continent, forcing a subduction zone to backstep to the other side of the oceanic plateau. An arc develops before more terranes collide with the outer edge of the oceanic plateau. (2) The oceanic plateau approaches a subduction zone, jams it, and forces the subduction zone to switch direction. An arc system forms on the oceanic plateau near the new subduction zone before the whole system undergoes subduction beneath and collision with a continent.

ARSENIC SPECIATION KIT DEVELOPMENT AND FIELD TESTING IN FOUR NEW MEXICO THERMAL AREAS, by Patricia L. Frisch, 2002, M.S. thesis, Department of Earth and Environmental Science, New Mexico Institute of Mining and Technology, Socorro, NM 87801, 140 pp.

This paper reports the development of two ion-exchange techniques for separating aqueous arsenic species. The first technique separates arsenite (As(III)) from arsenate (As(V)). Under laboratory conditions, the recovery of As(III) in the eluent is 98.8% ± 23.8%. The recovery of As(V) is 77.0% ± 29.7%. Standards ranged from 2 µg/l to 500 µg/l arsenic. Organic arsenic species coelute with As(III). The two-species separation method works well in the field. For 14 samples with total arsenic concentrations >10 µg/l, recoveries range from 66.7% to 120.0%, which is good.

The second ion-exchange method separates As(III), As(V), monomethylarsonic acid (MMA) and dimethylarsinic acid (DMA). Recoveries for individual species are comparable to the two-species method, but As(V) is not completely stripped from resin and elutes in the DMA range. Thus, there is false detection of DMA when As(V) is present.

The two-species method was used to gather new data on arsenic species in thermal waters. Four New Mexico regions, Jemez Mountains, Socorro, Bosque del Apache, and Truth or Consequences, were sampled. Total arsenic concentrations in the Jemez Mountains range from 33 µg/l to 1,100 µg/l. The percentage As(III) ranges from 5.6% to 94.8%. Higher total arsenic sites have greater As(III) proportions. Arsenic correlates positively with chloride, silica, TDS, temperature (from 33°C to 71°C), and Fe + Mn.

In the Socorro area, arsenic concentrations range from 2 µg/l to 36 µg/l. Arsenic is As(V). The three thermal springs (24.4°C to 33.1°C) contain the highest amount of arsenic in this region. Arsenic is inversely proportional to TDS; there are no correlations with other parameters.

In the Bosque del Apache, arsenic ranges from < 2 µg/l to 20 µg/l. Arsenic is found mainly as As(III), with percentages from 66.7% to 100%. Water temperatures range from 17°C to 32°C. Arsenic shows a negative relationship with TDS and a positive relationship with nitrate in some samples.

Arsenic levels are 2–3 µg/l in the Truth or Consequences area. Measurable species are As(V), but concentrations are mostly too low for speciation. Water temperatures range from 42°C to 44°C. Sample parameters cluster tightly for all samples.

There is no correlation between arsenic and thermal waters. There is a correlation between arsenic concentration and volcanic terranes.

MICROBIAL REDUCTION OF HEXAVALENT CHROMIUM UNDER VADOSE ZONE CONDITIONS, by Douglas S. Oliver,

Jr., 2001, M.S. thesis, Department of Earth and Environmental Science, New Mexico Institute of Mining and Technology, Socorro, NM 87801, 144 pp.

Improper disposal of hexavalent chromium [Cr(VI)] in arid and semi-arid regions has led to contamination of underlying vadose zones and aquifers. To remediate Cr(VI) contamination, soluble Cr(VI) can be reduced to insoluble Cr(III). The objectives of this study were to assess the potential for immobilizing Cr(VI) contamination using a native microbial community to reduce Cr(VI) to Cr(III) under conditions similar to those found in the vadose zone, and to evaluate the potential for enhancing biological reduction of Cr(VI) through the addition of nutrients.

Batch microcosm and unsaturated flow column experiments were performed. Native microbial communities in subsurface sediments with no prior Cr(VI) exposure were shown to be capable of Cr(VI) reduction. In both the batch and column experiments, Cr(VI) reduction and loss from the aqueous phase were enhanced by adding both nitrate (NO_3^-) and organic carbon (molasses). These results suggest that biostimulation of microbial Cr(VI) reduction by nutrient amendment is a promising strategy for remediation of Cr(VI)-contaminated vadose zones. This thesis presents a journal article, submitted to *Environmental Science & Technology*, that describes the experiments performed and discusses the results of these experiments. Supporting data for the journal article are provided in the thesis appendices.

INTEGRATED 3-D SEISMIC ANALYSIS OF ATOKA FORMATION SANDSTONE RESERVOIRS, VACUUM FIELD VICINITY, LEA COUNTY, NEW MEXICO, by Soichiro Ota, 2001, M.S. thesis, Department of Earth and Environmental Science, New Mexico Institute of Mining and Technology, Socorro, NM 87801, 145 pp.

Atoka Formation (Lower Pennsylvanian) sandstone reservoirs in the Delaware Basin of southeastern New Mexico are generally considered to be very unpredictable targets for natural gas exploration. This study applies an integrated methodology, combining geology, petrophysics, and seismic interpretation to successfully describe and map this problematic formation in the Vacuum field vicinity, Lea County, New Mexico. The area of interest for this thesis is a four township area (T17–18S R34–35E). Most Atoka Formation production, cumulatively more than 4 billion ft^3 of natural gas, is from T17S R35E. This study examined both the larger and the more focused area of interest. The dataset available for this study included cores, petrophysical well logs, and a 109 mi^2 3-D reflection seismic volume. The advantage of studying the well data is to glean key small-scale information that is below seismic resolution, and provide geological constraint to the seismic interpretation through the creation of synthetic seismograms and a geology-based seismic model. Seismic data interpretation yielded information related to geologic structure and tectonic development, stratigraphic subdivisions of the Atoka Formation, and most importantly, the distribution of reservoir-potential sandstone; most of this information could not be derived from the available well data alone.

The Atoka Formation in the area of interest, on the Northwest shelf of the Delaware Basin, is primarily clastic, sandwiched between overlying Strawn Formation limestone and underlying Morrow Formation limestone. The Atoka Formation can be subdivided into lower Atoka fluvial deposits and upper Atoka deltaic to marine strata. The upper Atoka Formation is marked by cyclic upward-coarsening, clastic sequences that represent delta progradation following episodic marine flooding events marked by black, organic shale and limestone. The lower Atoka Formation consists of stacked, vertically aggraded fining-upward, fluvial depositional sequences, and can be divided into the "upper sand" and "lower sand." Only the lower sand has demonstrated reservoir characteristics. It was deposited in meandering fluvial channels confined to two incised channel belts, whereas the upper sand's northeast-trending meandering channels were unconfined and free to migrate across a broader floodplain from southeast to northwest, with migration reflecting local tectonic tilting.

The methodology used to understand the Atoka Formation, recommended for wider application in the region, consists of: (1) Understand geologic constraints by using all well data available to build a geologic model for constraining the seismic interpretation; (2) Use synthetic seismograms for correlating log-to-seismic data—identification of the exact wavelet corresponding to sand bodies is critical for success; (3) Build a seismic model that must work from a theoretical sense, from geologic data available, and from the seismic volume. In this case, thick sandstone (>20 ft) is vertically resolvable and can be mapped by the presence of an extra trough and related amplitude anomalies according to the bed thickness model; (4) Apply coherency analysis to the seismic volume as the best tool for revealing channels; and (5) Amplitude attribute extraction demonstrates thickness variations within channels/channel belts.

STRUCTURAL GEOLOGY AND HYDROGEOLOGIC CHARACTERIZATION OF FAULTS IN POORLY LITHIFIED SEDIMENTS, by Geoffrey Callis Rawling, 2002, Ph.D. dissertation, Department of Earth and Environmental Science, New Mexico Institute of Mining and Technology, Socorro, NM 87801, 223 pp.

In this study I integrate field and microstructural observations, field and laboratory permeability measurements, and analytical and numerical hydrologic models to understand the structural development, operative deformation mechanisms, and impact on subsurface fluid flow of normal faults in poorly lithified sediments. The study sites are faults cutting sediments of the Tertiary Santa Fe Group in the Albuquerque and Socorro Basins of the Rio Grande rift, central New Mexico, U.S.A.

These fault zones do not contain macroscopic fractures; they are characterized by deformation bands where they cut sandy sediments. The fault cores are composed of foliated clay flanked by structurally and lithologically heterogeneous mixed zones, in turn flanked by damage zones. Structures present within these fault-zone architectural elements are different from those in brittle faults formed in lithified sedimentary and crystalline rocks, which do contain fractures. Mixed zones are structurally and hydrologically heterogeneous, and are not present in brittle faults in crystalline and well-lithified sedimentary rocks. Sediment is initially incorporated into mixed zones by processes typical of brittle faults (e.g., asperity and tipline bifurcation), and may be continually added throughout the movement history of the fault. Mixed zones exhibit macroscopically ductile structures formed by penetrative particulate flow. In sand-rich lithologies, these are overprinted by deformation bands, which represent a later, more localized style of deformation. These structures and overprinting relationships are consistent with the inferred consolidation history of the faults and their host sediments.

Microscopic observations reveal that the mode of grain fracture within the fault zones is controlled by relative grain strength. Transgranular fracturing of quartz is rarely observed. Rather, quartz typically deforms by flaking of grain edges, feldspar by transgranular fracture facilitated by cleavage, and lithic fragments by transgranular fracture or distributed microcracking. Particle size measurements indicate that progressive deformation produces particle size distributions that can be described by power-law models, characterized by low D values (1.7–2.1). This indicates that the particle size distributions have proportionally more large particles than would be expected from cataclasis by constrained comminution (D ~2.6). I interpret the results in terms of cataclastic deformation by controlled particulate flow under low confining pressure, in which extensive transgranular fracturing is not necessary for strain accumulation. This style of cataclastic deformation is different from the transgranular fracturing observed in crystalline and lithified sedimentary rocks.

The structural differences between faults with deformation bands in poorly lithified sediments such as the Sand Hill fault and faults with fractures in crystalline and lithified sedimentary rocks are reflected in the permeability structures of the two fault-zone types. Equivalent permeability calculations indicate that the large-displacement normal faults in poorly lithified sediments examined in this study have little potential to act as vertical fluid-flow conduits and have a much greater effect on horizontal fluid flow than faults with fractures.

Numerical flow models indicate that fluid flow in faults with fractures in lithified sedimentary rocks is concentrated in fracture-rich damage zones, which allow extensive vertical redistribution of flow. Faults with mixed zones in poorly lithified sediments are more effective barriers to horizontal flow. Flow is induced in low permeability layers adjacent to such faults, and there is less potential for vertical redistribution, or focussing, of flow within the fault zone. Increasing the internal fault zone complexity and varying the thickness of the host strata have only secondary effects on fault-related fluid flow patterns for both fault types. Three-part fault-zone models therefore appear adequate to provide simulations of fluid-flow patterns in basin-scale numerical flow models.

A UNIFYING CONCEPTUAL MODEL TO DESCRIBE WATER, VAPOR AND SOLUTE TRANSPORT IN DEEP ARID VADOSE ZONES, by Michelle Walvoord, 2002, Ph.D. dissertation, Department of Earth and Environmental Science, New Mexico Institute of

Mining and Technology, Socorro, NM 87801, 297 pp.

Current understanding of the movement of water and solutes in deep desert vadose zones represents a major knowledge gap among the hydrologic science community. A particularly critical aspect in closing this gap is supplying a hydrologic framework that explains both matric potential and chloride vadose zone profiles typically observed beneath interdrainage regions of desert floors. This research seeks to close that gap. The conceptual model of deep arid system hydrodynamics (DASH), formulated as part of this study, relies on vapor transport and the hydrologic role of desert plants that have become established during the past 10–15 thousand yrs in the southwestern U.S. as critical elements in explaining the observations. According to the DASH model and supported by field observations, desert vegetation sustains very negative matric potentials at the base of the root zone and effectively buffers the deep vadose zone over very long time scales from most hydrologic near-surface transients, such as episodic precipitation events. A nonisothermal, multiphase flow and transport code, FEHM, is used to numerically simulate the DASH conceptual model and other conceptual flow models previously proposed. Model results generated using the DASH paradigm match both characteristic matric potential profiles and chloride profiles, whereas model results generated using the other conceptual models that were tested deviate dramatically from observed matric potential data. A unifying theory for the hydrology of desert vadose zones is particularly timely considering current water stresses and contaminant issues associated with desert regions.

A sensitivity analysis tests the applicability of the DASH model to a wide range of desert vadose zone parameters and conditions. The sensitivity analysis also enables assessment of the factors that control moisture movement in deep vadose zones. The results indicate that most thick desert vadose zones have been locked in slow drying transients for many thousands of years, since the desert vegetation became established. A hydrodynamic condition, as opposed to a hydrostatic condition, characterizes deep vadose zones in equilibrium with the dry hydraulic conditions imposed by desert vegetation. Long response times, on the order of 104–106 yrs, are required to reach this hydrodynamic equilibrium, which exceeds the typical time scale of major climate shifts.

Two case studies demonstrate the application of the DASH model to interpretation of measured hydraulic and solute profiles from deep arid vadose zones. The DASH model approach enables paleohydrologic reconstruction and yields information about current vapor and liquid fluxes between the base of the root zone and the water table. Both case studies emphasize the influence of desert vegetation on deep vadose zone hydrodynamics. Desert vadose zone hydraulic profiles cannot be resolved apart from their climate and vegetation histories.

New Mexico State University

REGIONAL ANALYSIS OF THE DEPOSITIONAL ENVIRONMENTS OF THE YESO AND GLORIETA FORMATIONS (LEONARDIAN), NEW MEXICO, by Philip A. Dinterman, 2001, M.S. thesis, Department of Geological Sciences, New Mexico State University, Las Cruces, NM 88003, 165 pp.

The Yeso and overlying Glorieta Formations (Lower Permian, Leonardian) were examined throughout the state of New Mexico with the goal of interpreting a regional depositional model. The basal member of the Yeso Formation, the Meseta Blanca, consists of crossbedded sandstones deposited as eolian dunes in the northeastern part of the state, and a broad region in the central part of the state of windrippled sandstone and green sandstone and shale with halite casts deposited in eolian sand sheets and coastal salinas. Fluvial sediments, represented by broad shallow channels are rare and restricted to the northern half of the state. Strata coeval to the Meseta Blanca Member in the southeastern part of the state contain a mixture of eolian sandstones and marine gypsum and carbonates. The middle members of the Yeso Formation consist of interbedded eolian sandstone, shoreface sandstone, peritidal dolomite, lagoonal dolomite and laminated gypsum, and marine limestone. The upper members of the Yeso, the Joyita and San Ysidro, represent an eolian sand sheet.

Unlike subarkosic sandstones of the Yeso Formation, which were derived from the Ancestral Rocky Mountains, the quartzose sand of the Glorieta Formation was derived from Pennsylvanian sandstones exposed far to the north. The quartz sand was transported southward by longshore currents and then blown onto land in the Four Corners region. The Glorieta Formation is mixed eolian and marine in the northern part of New Mexico but is entirely marine in central New Mexico, eventually pinching out before reaching the southern part of the state.

By Leonardian time, the Ancestral Rocky Mountains were substantially reduced in relief, and the Pedernal uplift was onlapped by Yeso sediment. The Caballo arch is postulated to have provided a barrier separating thick, gypsum-rich sediment of the Yeso from thinner sediments to the west that lack gypsum. Widespread eolian and evaporite deposition in the Yeso indicates an arid climate, an interpretation that is at odds with some paleoclimatic models and with a paleolatitudinal position a few degrees north of the equator. The Yeso records a marine transgression that culminated with deposition of the limestone member and correlative units as far north as the Zuni Mountains, followed by progradation of an eolian sand sheet of the Joyita Member into central New Mexico. A second transgression is indicated by deposition of marine sands of the overlying Glorieta Formation and overlying San Andres Limestone.

ANALYSIS OF THE GROWTH STRATA OF THE UPPER CRETACEOUS TO LOWER PALEOGENE POTRERILLOS FORMATION ADJACENT TO EL GORDO SALT DIAPIR, LA POPA BASIN, NUEVO LEON, MEXICO, by David W. Mercer, 2002, M.S. thesis, Department of Geological Sciences, New Mexico State University, Las Cruces, NM 88003, 229 pp.

Near-surface salt diapiric rise influenced depositional patterns within La Popa Basin of northeastern Mexico. Outcrop exposures at El Gordo diapir, located approximately 70 km northwest of Monterrey in Nuevo Leon, Mexico, permit direct examination of sedimentation adjacent to a salt diapir. At El Gordo, three carbonate horizons (lentils), lower, middle, and upper Gordo, are exposed within mudstone units of the Potrerillos Formation. Geologic mapping, measured sections, and thin section analysis were utilized to study growth strata at El Gordo diapir.

Carbonate lithofacies were organized into five lithofacies associations. Lower and upper Gordo lentils trend from reef to fore reef to turbidite facies as they grade away from the diapir. Middle Gordo lentil comprises a subaqueous debris flow on the western side of the diapir that contains blocks of lower Gordo lentil and extends as a thin carbonate horizon on the eastern side. Reef development is more prolific along the western and northern margins of the diapir than along the eastern margin. Carbonate lentils are thickest near the diapir and thin rapidly away from the diapir to where they merge with encasing mudstone.

Comparison of Potrerillos Formation stratigraphy between El Gordo diapir and the previously studied El Papalote diapir indicates that three, thicker halokinetic sequences were deposited at El Gordo diapir, whereas six are present at El Papalote diapir. El Gordo diapir is located in the hinge of an Hidalgoan fold, which partially resulted in it standing higher bathymetrically than El Papalote diapir. The location of the diapirs relative to the fold and the local differences in bathymetry are the primary reasons for differences in deposition between the two diapirs.

Eustacy was not a major influence on sedimentation adjacent to the diapir. Rather, sedimentation adjacent to the diapir was primarily controlled by diapiric rise and the resulting bathymetry. However, local sea level adjacent to the diapir would have influenced carbonate facies development. The interbedded nature of siliciclastic units and carbonate horizons at El Gordo diapir does not appear to be controlled by regional sedimentation patterns. Regional tectonic activity indirectly changed the local sedimentation patterns by affecting the geometries of the diapirs through shortening.

A RECONNAISSANCE EVALUATION OF CHEMICAL MODEL SIMULATIONS OF METAL-ORGANIC COMPLEXATION IN NATURAL WATERS, by Lynn Marie Sabido, 2002, M.S. thesis, Department of Geological Sciences, New Mexico State University, Las Cruces, NM 88003, 195 pp.

Metal-organic complexes in geochemical systems are important because they affect the general behavior of metals in aqueous environments, including their bioavailability and toxicity. Various chemical models in the form of computer programs have been developed to predict the formation and concentration of complexes in solution, the concentration of free ions in solution, and the overall speciation of dissolved components. In recent years these codes have been used to investigate various chemical systems in natural and hypothetical aqueous solutions.

The purpose of this study is to evaluate the effectiveness of various chemical models in simulating metal-organic interactions in geochemical systems, and to propose how individual computer codes of these models can be improved. The computer program selection process used in this study was based on the abil-

ity to speciate metal-organic complexes, specific program characteristics, program limitations, and ease of program operation. This selection process narrowed the number of computer codes used for this study from 11 down to four. As part of this study, two metal-organic databases were developed, including a recommended database, comprising the necessary stability constants data (log K) needed to modify the databases of the four test programs.

The four test programs chosen (Solveq, Eq3, Minteqa2, and Solmineq.88) were evaluated and compared through three series of tests that focused on their capability to model metal-organic complexation for a series of natural and artificial waters that contain organic ligands. These tests were designed to (1) compare the speciation results of the four test programs using their original databases and to determine which databases needed to be modified by including additional metal-ligand species and (2) to perform sensitivity tests that evaluate metal and ligand competition on metal-organic complexation and how aqueous speciation is affected by varying selected aspects of the chemical model (i.e. activity coefficient equations, if solids were allowed to precipitate, and further updating of metal-ligand log K values).

In this study it was found that the four test programs are able to adequately simulate metal-organic complexation in natural waters. Differences among program output are attributed to differences in (1) inorganic species in each database, (2) organic species in each database, (3) the log K values of the inorganic and organic species, and (4) the program algorithm. The results of this study clearly show that if two different programs contained the same set of metal-ligand species and their corresponding log K values, significant differences in speciation output would still arise due to the differences in the inorganic parts of each program's database. Eq3, Minteqa2, and Solveq allow the user to easily modify the database and give the user more freedom when creating input files that are better equipped to model metal-organic ligand speciation. It was also found that Eq3 and Minteqa2 can adequately model metal-organic complexation under a wide variety of geochemical conditions, whereas Solveq and Solmineq.88 have a narrower use when it comes to water types. Further testing of Minteqa2 and Eq3 programs should be considered because they have large organic and inorganic databases. These tests should include sensitivity testing of natural systems including titration calculations, changes in system parameters such as pH, temperature, and ionic strength calculations, and variations in organic concentration.

THE INFLUENCE OF DIAPIRISM AND FORELAND EVOLUTION ON THE DEPOSITIONAL SYSTEM, STRATIGRAPHY, AND PETROLOGY OF THE MAASTRICHTIAN MUERTO FORMATION, LA POPA BASIN, MEXICO, by Amy Leigh Weislogel, 2001, M.S. thesis, Department of Geological Sciences, New Mexico State University, Las Cruces, NM 88003, 310 pp.

The Muerto Formation represents the first, coarse-grained synorogenic deposits of the 5.6 km thick Difunta Group in the La Popa Basin of northeastern Mexico. Data from eight measured sections of the Maastrichtian Muerto Formation reveal that lithofacies relationships and sequence stratigraphic evolution were controlled locally by halokinesis associated with the development of the El Gordo evaporite diapir. On a regional scale, the sequence stratigraphic evolution and petrologic evolution are controlled by eustacy and tectonism associated with the development of the Hidalgoan orogen. Twenty-four lithofacies comprise four depositional facies assemblages: (1) shoreface, (2) tidal; (3) lagoonal, and (4) lower delta plain. These facies assemblages comprise the Muerto delta, a tidally influenced barrier-island system resembling the modern Niger River delta. The Muerto Formation is composed of three complete third-order sequences and one partial sequence, with the basal contact produced by an eustatic sea level drop at approximately 75 Ma. Stratigraphic geometries within the Muerto Formation adjacent to the El Gordo diapir are a function of the rate of diapir rise (R_{net}) and the rate of sediment accumulation (A_{sed}). During rapid rises in sea level, R_{net} is greater than A_{sed}, and the locus of deposition shifts away from the diapir, such that onlapping geometries are produced during development of transgressive systems tracts. With the onset of deposition of the highstand systems tract, A_{sed} greatly exceeds R_{net}, and accommodation space is created by erosion of the previously deposited transgressive systems tract in the diapir-proximal and intermediate zones.

The Muerto Formation is composed of subequal proportions of quartz, feldspar, and lithic grains. The abundance of plagioclase and lathwork volcanic lithic grains and the presence of albite are consistent with derivation from the accreted Guerrero/Arperos composite terrane and minor contemporaneous volcanism. Vertical compositional variations indicate that initiation of foreland deformation uplifted the Guerrero/Arperos composite terrane; subsequent propagation of the incipient Sierra Madre Oriental introduced sedimentary lithic fragments into the basin, with a subordinate amount of detritus still being derived from the Guerrero/Arperos source. Continued hinterland denudation and thrusting produced alternating influxes of Guerrero/Arperos-derived sediment and Sierra Madre Oriental-derived sediment.

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A LATE QUATERNARY HIGH-RESOLUTION GLACIAL AND PALEOCLIMATE RECORD FROM THE SOUTHERN SANGRE DE CRISTO MOUNTAINS, NORTHERN NEW MEXICO, by Jake Armour, 2002, M.S. thesis, Department of Earth and Planetary Sciences, University of New Mexico, Albuquerque, NM 87131, 161 pp.

Bog deposits in the Winsor Creek drainage basin, southern Sangre de Cristo Mountains, New Mexico, contain a high-resolution record of Pleistocene to Holocene glacial activity. Sediment cores were recovered from an alpine bog (elevation 3,100 m) behind a Pinedale age moraine 2 km from a high-elevaion (~3,600 m) cirque. Three cores reached glacial talus and consist of ~6 m of finely laminated to coarsely laminated lake clays, grading into gyttja. Superimposed on this long-term, lake-bog transition record are many distinct coarse-grained detrital packages punctuating times of rapid environmental change.

Accelerator mass spectrometry (AMS) carbon dating, sedimentology, variations in rock magnetic properties of the sediment, and organic carbon properties reveal six distinct periods of glacial/periglacial activity often correlative with detrital sand deposition. These include a late Pleistocene Pinedale glacial termination (>12,120 ^{14}C yr B.P.), a Younger Dryas cirque glaciation (~10,100 ^{14}C yr B.P.), an early Neoglacial periglacial event (~4,900 ^{14}C yr B.P.), a middle Neoglacial cirque glaciation (3,700 ^{14}C yr B.P.), and periglacial activity during late Neoglacial (2,800 ^{14}C yr B.P.) and Little Ice Age time (~120 ^{14}C yr B.P.). The age model from these cores indicates an increase in depositional rates immediately following glacial events, and a prolonged period of reduced deposition rates during the mid-Holocene warm period. Cold events documented in these cores correlate with times of reduced ice rafting events in the North Atlantic Ocean suggesting that these climatic changes were likely hemispheric in their extent.

The extreme southern position of this glaciated range and the absence of correlative glacial conditions in the more northerly, higher elevation, San Juan Mountains of Colorado suggest a climatic discontinuity exists. Modern differential effects of summertime land surface heating on atmospheric temperatures could explain this apparent paradox. A similar strong climatic gradient during the late Holocene would have led to contrasting climatic responses in the San Juan and the southern Sangre de Cristo Mountains. A summer temperature threshold is postulated to have existed between these two ranges, allowing small glaciers to grow on the periphery and not in the central part of the northern Colorado Plateau.

BIOGEOCHEMICAL AND HYDROGEOCHEMICAL STRUCTURE OF AN ALLUVIAL AQUIFER WITH EMPHASIS ON REDOX CONDITIONS AND ANNUAL CYCLING OF IRON AND MANGANESE, by Armand Rossini Groffman, 2001, Ph.D. dissertation, Department of Earth and Planetary Sciences, University of New Mexico, Albuquerque, NM 87131, 197 pp.

We have investigated the linkages between annual precipitation cycles, infiltration, and the hydrochemical response of shallow ground water at the Rio Calaveras research site in the Jemez Mountains of northern New Mexico. Redox conditions within the aquifer are transient, and the distribution of terminal electron acceptors (TEAs) shift in time and space throughout an annual cycle. The general pattern shows oxidizing conditions in the upper 20 cm of the aquifer during spring infiltration when dissolved oxygen is present in measurable concentrations. Manganese and iron are present at depth but are diminished in the upper aquifer during the spring. Following spring snowmelt infiltration, suboxic to anoxic conditions prevail throughout much of the year. Iron and manganese reduction as well as sulfate reduction, methanogenesis, and the production of reduced gases occur during this time. Maximum iron reduction and oxidation take place in the region where the water table fluctuates annually. Concentrations of soluble iron and sediment bound ferric iron were observed to be highest within this region. Sulfate reduction was observed to be highest in this zone as well with concentrations less than 2 mg/l observed during base flow conditions. When

detected, low molecular weight organic acids (labile organic carbon) were highest in the upper 50 cm of the aquifer with the greatest concentrations coinciding with post spring infiltration and summer primary production.

Redox processes at Rio Calaveras are controlled by the availability of organic carbon and distribution of TEAs in the aquifer. Although redox gradients generally follow a traditional pattern, superimposed redox regimes were observed where manganese, iron, and sulfate reduction, as well as methane generation, were observed to be taking place in the same region of the aquifer, especially during the summer. This indicates that when ample labile organic carbon is available, the limiting factor becomes the availability of the TEAs within the aquifer. Microbially mediated iron and manganese reduction are thought to be the predominant processes controlling redox conditions in the aquifer at Rio Calaveras throughout much of the year.

THE MICROVERTEBRATE RECORD OF THE UPPER TRIASSIC LOWER CHINLE GROUP (CARNIAN), SOUTHWESTERN U.S.A. AND THE EARLY EVOLUTION OF DINOSAURS, by Andrew B. Heckert, 2001, Ph.D. dissertation, Department of Earth and Planetary Sciences, University of New Mexico, Albuquerque, NM 87131, 465 pp.

This dissertation has two major components: (1) a detailed analysis of thousands of microvertebrate fossils from seven localities of Otischalkian (early late Carnian) to Adamanian (latest Carnian) age in the Upper Triassic Chinle Group; and (2) a comprehensive study of the fossil record, biostratigraphy, biochronology, and evolution of Triassic dinosaurs.

The localities are the *Trilophosaurus* quarry and two sites near Kalgary in west Texas, Ojo Huelos and Sixmile Spring in New Mexico, and the Blue Hills and Dying Grounds in Arizona. Sampled depositional environments include channels, floodplains (including paleosols), and lakes. The fossils include chondrichthyans, osteichthyans, amphibians, and amniote tetrapods, and include six new species in four new genera and 38 new records of family- or lower-level taxa. Here I name the hybodont shark *Diplolissodus murryi* n. gen. et sp., the sphenodontian lepidosaurs *Llanosaurus fraseri* n. gen. et sp. and *Planocephalosaurus lucasi* n. sp., and the ornithischian dinosaurs *Protecovasaurus lucasi* n. gen. et sp., *Crosbysaurus harrisae* n. gen. et sp., and *Revueltosaurus hunti* n. sp. The new records include selachians (5), osteichthyans (9), amphibians (2), and 22 new records of procolophonids, cynodonts, sphenodontians, *Trilophosaurus buettneri*, diverse archosauriform reptiles, and dinosaurs.

The first appearance of dinosaurs is essentially synchronous during the Otischalkian. Dinosaurs diversify rapidly and occur in strata of Adamanian age across Pangea. During Revueltian (early-mid Norian) time dinosaurs are locally common components of terrestrial faunas. By Apachean (latest Norian) time dinosaurs are the most common tetrapods in non-equatorial terrestrial basins.

The evolution of dinosaur size, locomotion, dentition, and physiology, as well as paleoclimatology, tetrapod paleobiogeography, and putative extinction events, demonstrate that dinosaurian success in the Triassic is complex, but not an opportunistic response to extinction events. Dinosaurs are part of a diapsid-dominated radiation. Within Diapsida, lepidosauromorphs remain small (<10 kg), whereas archosaurs, with their upright posture, fill large-bodied (>10 kg) niches. Among archosaurs, dinosaurs undergo additional locomotor evolution favoring agility (theropods) and great size (prosauropods) and are the only group to evolve two lineages of upright herbivores (prosauropods and ornithischians). Consequently, the rise of the dinosaurs was no "accident," but instead an adaptive radiation into previously unoccupied ecospace during the Late Triassic.

THE PROTEROZOIC ANCESTRY OF THE COLORADO MINERAL BELT: CA 1.4 GA SHEAR ZONE SYSTEM IN CENTRAL COLORADO, by Annie Marie McCoy, 2001, M.S. thesis, Department of Earth and Planetary Sciences, University of New Mexico, Albuquerque, NM 87131, 160 pp.

The Paleocene to Oligocene magmatism and mineralization that are the Phanerozoic expressions of the Colorado mineral belt developed along a northeast-trending system of subvertical mylonites and ultra mylonites that formed in the Mesoproterozoic and that, in turn, overprinted higher-temperature Paleoproterozoic high strain zones of similar orientation. In this thesis, I distinguish the Colorado mineral belt itself from a Proterozoic "Colorado mineral belt shear zone system" that includes the Homestake, Gore Range, St. Louis Lake, and Idaho Springs–Ralston shear zone segments. In situ electron microprobe monazite dating of mylonites of the Colorado mineral belt shear zone system, coupled with field studies of relative timing of shearing and pluton emplacement, demonstrate a ca 100 Ma history of recurrent shearing. This history involves movement at 1.45 Ga along Idaho Springs–Ralston shear zones and possibly along Homestake shear zone, synchronous with emplacement of the Mt. Evans pluton. At 1.42 Ga, movement took place along St. Louis Lake and again along Idaho Springs–Ralston shear zones, synchronous with emplacement of the Silver Plume pluton.

At 1.38 Ga, movement took place along Homestake and Idaho Springs–Ralston shear zones, synchronous with emplacement of the St. Kevin pluton, and post-1.38 Ga movements reactivated Homestake, St. Louis Lake, and Idaho Springs–Ralston shear zones. In each shear zone segment, kilometer-wide Mesoproterozoic mylonite zones consist of multiple, parallel, 1–10 m-wide mylonite strands, which overprint higher-temperature Paleoproterozoic high-strain domains that are several kilometers wide. Monazite dating of the higher temperature high-strain domains indicates pulses of Paleoproterozoic deformation that occurred at 1.71–1.69 Ga, 1.67 Ga, 1.65 Ga, and 1.62 Ga. Thus the tectonic fingerprint of the Colorado mineral belt shear zone system includes two ~100 Ma long orogenic periods in the Proterozoic, each with important pulses of deformation that occurred every 15–20 m.y. This shear zone system may be analogous to modern-day intracontinental zones of weakness like the Tien Shan, which record both original assembly of tectonic blocks and reactivation of intracontinental weaknesses during later plate convergence at a distant margin.

RELATING VEGETATION VARIABILITY TO METEOROLOGICAL VARIABLES AT THE SEVILLETA NATIONAL WILDLIFE REFUGE, NEW MEXICO, by Jeremy L. Weiss, 2002, M.S. thesis, Department of Earth and Planetary Sciences, University of New Mexico, Albuquerque, NM 87131, 166 pp.

Spring and summer relationships between spectral characteristics of vegetation and meteorological variables are examined at six different sites of the Sevilleta Long-term Ecological Research (LTER) site and National Wildlife Refuge in central New Mexico, U.S.A. Using the normalized difference vegetation index (NDVI) derived from advanced very high resolution radiometer (AVHRR) remote sensing images, time series data from 1990 through 2000 are constructed for Great Plains grassland, Chihuahuan desert, piñon-juniper woodland, juniper savanna, Colorado Plateau shrub-steppe, and Colorado Plateau grassland biomes. The resulting time series show interannual variability for a given biome and considerable spatial coherence amongst the biomes for a given year.

The 5-km diameter analysis area of each of these biomes is centered on meteorological stations with matching data records. Meteorological variables measured at the stations, reduced through factor analysis to three fundamental variables of mean maximum temperature, maximum wind speed, and precipitation, serve as predictor variables in linear multivariate regression analyses. Significant information appears in multiple regression models despite small temporal sample sizes.

All three meteorological factors are significant in determining NDVI variability. Possible causes for the predictor variables are presented based on results available in ecological and botanical literature. Predictor variables with seasonal and interannual time lags show that vegetation acts as a source of both short- and long-term memory in the climate system. The results from this exploratory data analysis provide insight into important interactions between local vegetation and the meteorological regime, demonstrating complex relationships between vegetation growth and the local climate system. Furthermore, the results from this study can be used to suggest hypotheses for regional effects of vegetation-atmosphere interactions, as the examined biomes cover large areas of southwestern North America.

A TAPHONOMIC ANALYSIS OF A FIRE-RELATED LATE TRIASSIC DEATH ASSEMBLAGE, by Kate E. Zeigler, 2002, M.S. thesis, Department of Earth and Planetary Sciences, University of New Mexico, Albuquerque, NM 87131, 124 pp.

The Snyder quarry is a unique Late Triassic bonebed located near Abiquiu in north-central New Mexico. The locality is stratigraphically high in the Petrified Forest Formation of the Chinle Group. Tetrapod biostratigraphy places the quarry in the Revueltian land-vertebrate faunachron, which is mid-Norian, (~210–215 Ma). This locality has yielded the remains of a wide variety of organisms, including phytosaurs, aetosaurs, theropod dinosaurs, reptiles, fish, bivalves, conchostracans, and decapods as well as plant material.

A taphonomic analysis of the skeletal and plant material, as well as the sedimentology of

the quarry reveals that this deposit is the result of a catastrophic mass mortality event. The sediments of the deposit contain rip-up clasts from the surrounding floodplain, a significant portion of the bone and wood is aligned, there is a high density of bones over a large area, and there is a moderate degree of hydraulic sorting of the skeletal material. These data are evidence for a very rapid movement and deposition of the bonebed. There is no evidence of abrasion on the bones, and there is a significant amount of charcoal, which is buoyant, indicating that transport was minimal.

The skeletal material is associated, and in rare cases articulated, indicating that the animals were in a state of partial decay before transport and deposition. There is no evidence of weathering of the bones or of vertebrate scavenging, which is evidence for the rapid burial of the material. Also, an age profile was constructed for the phytosaurs, revealing a high percentage of subadult or young adult animals. The preponderance of young adult phytosaurs is unusual, given that these individuals would be the strongest members of the animal community. A death assemblage that is derived from an ecosystem through attritional processes will contain the remains of the very young and the very old members, as these are the individuals that are most susceptible to disease and predation.

Scanning electron microscopy and reflectance microscopy work on the charcoalized wood show that the internal structure of the cell walls has been homogenized and the reflectance of the material is substantially higher than other forms of coal, indicating that the wood was burned in a moderate temperature ground fire. Thus, the evidence from the Snyder quarry deposit best fits the scenario of a catastrophic Late Triassic wildfire.