

SELECTED ABSTRACTS FROM THE 1997 NATIONAL SPELEOLOGICAL SOCIETY CONVENTION IN SULLIVAN, MISSOURI

BIOLOGY SESSION

CAVE WILDLIFE IN MISSOURI'S BIG SPRING COUNTRY—AN OVERVIEW
Michael Sutton, Route 1, Box 110A, Annapolis, MO 63620

The watersheds of the Current and Eleven Point Rivers in the southeastern Missouri Ozarks form one of the most intensely karstic regions in the state. In a program that originated in 1990 with concern over the effects of mineral exploration, the Cave Research Foundation has been systematically mapping caves and performing macrofaunal surveys within the Eleven Point watershed on the Mark Twain National Forest. The caves range up to 1.6 km (1 mi.) in length and vary from small remnant channels to large base-level stream caves. About 160 caves have been examined. The habitat is very food limited, as recharge takes place through a thick mantle. Typical stream fauna includes low densities of troglobitic isopods (*Caecidotea antricola*) and two species of *Stygobromus* amphipods. Added to this may be troglobitic fish (*Typhlichthys subterraneus*) and crayfish (*Cambarus hubrichti*) and troglolophilic snails. The amphibian fauna is relatively diverse. Cave, long-tailed and grotto salamanders are all common, frequently within the same cave. An unexpected factor is the use of stream caves by beavers, often an important source of nutrients. Gray bats colonize a dozen caves, including some newly recorded sites. Terrestrial invertebrates include widespread species such as the fungus beetle *Ptomophagus cavernicola*, and the flightless fly *Spelobia tenebrarum* as well as a diverse mixture of springtails, mites, rove beetles, etc. Several previously unrecorded species occur. This attempt to look comprehensively at all caves in a relatively large area is helping to build a broad overview of the regional cave fauna.

HETEROTROPHIC DOMINANCE OBSERVED AMONG THE MICROORGANISMS OF THE SCHERMERHORN PARK CAVE IN CHEROKEE COUNTY, KANSAS
Rod Samuelson, McPerson College, McPerson, Kansas

Although the Schermerhorn Park Cave, in Cherokee County, is considered the most biologically diverse cave in Kansas, the microfauna of the cave does not diverge significantly from the nearby soil, and the cave's inhabitants rely primarily on the surface for their supply of organic nutrients. Analysis of water samples through bacteria density plate counts, metabolic and morphologic tests on isolated bacteria, and a quantitative water analysis provided by the Kansas Department of Health and Environment gave a preliminary survey of the underground bacteriology of the cave. The bacteriological tests revealed an abundance of heterotrophic bacteria in samples collected from the stream origin and an isolated pool. The water analysis showed levels of essential nutrients and toxins for iron oxidizing bacteria that diverge significantly from optimum conditions. Therefore, it seems that the Schermerhorn Park Cave is dominated by heterotrophic organisms, that the cave's microenvironment closely resembles the soil, and that large regions containing an abundance of chemolithoautotrophs do not exist.

NOTES ON BIOGEOGRAPHY, ECOLOGY AND BEHAVIOR OF MEXICAN BLIND CATFISH, GENUS *PRIETELLA* (ICTALURIDAE)

D. A. Hendrickson & J. K. Krejca, Texas Natural History Collections/R4000, University of Texas, Austin, TX 78712-1100

The Mexican blind catfish *Prietella phreatophila* Carranza 1954, is an obligate troglobitic catfish, formerly thought endemic to springs adjacent to, or within about a 50 km radius of, the town of Muzquiz, in central Coahuila. Specimens have been rare, and generally little is known of the biology of the genus. Several characters, however, place the genus as the sister group to *Noturus*, indicating a probably ancient divergence from the common ancestor perhaps related to cave invasion. Recent discoveries of congeneric populations far to the northwest (near the Texas border) and southeast (in southernmost Tamaulipas) extend the range across more than 600 km, transecting many major surficial drainages and major mountain ranges. Preliminary morphological observations indicate that the northern population differs little from *P. phreatophila*, but the single specimen from the southernmost locality was recently described as *Prietella lundbergi* Walsh and Gilbert 1995.

HUMAN IMPACT ON THE MICROBIAL COMMUNITIES OF LECHUGUILLA CAVE: IS PROTECTION POSSIBLE DURING ACTIVE EXPLORATION?

Diana E. Northup, Kathylyn M. Beck, & Lawrence M. Mallory, University of New Mexico, Biomes, Inc.

In an effort to assess the impact of humans (explorers and scientists) on the microbial communities of Lechuguilla Cave, Carlsbad Caverns National Park, New Mexico, the authors undertook a study of selected human indicator species of bacteria. We compared low impact (alcoves, off-trail sites) with high human impact areas (camps, trade routes, rocks that humans slither over, urine dumps, drinking water sources). Enrichment culture procedures targeted high-temperature *Bacillus* sp., *Escherichia coli*, and *Staphylococcus aureus* sampled from these sites. High-temperature *Bacillus* are bacteria that one would expect to find on the surface in high-temperature desert soils, but would not expect to find in the soils of the cave which remain at a stable 20°C. Results of these comparisons show that high human impact areas have significantly more of the human indicator species than do the low impact areas. Some recovery is seen in areas with *S. aureus* and *E. coli* if the areas are given a rest from human visitation, giving time for the human-associated bacteria to die off.

THE ECOLOGY OF TEXAS CAVE CRICKETS

William R. Elliott, Texas Memorial Museum, The University of Texas at Austin, 12102 Grimsley Drive, Austin, Texas 78759-3120

The raphidophorid genus *Ceuthophilus* has numerous described and undescribed species in Texas caves. Three species are sympatric in caves along the Balcones Fault Zone in Central Texas. *Ceuthophilus* (*C.*) *secretus* Scudder and *C.* (*C.*) new species "B" both roost on ceilings and forage outside, while *C.* (*Geotettix*) *cunicularis* Hubbell is a floor-dweller that rarely ventures outside. Crickets will emerge most evenings when the air is >16°C. The "cricket hop" usually starts within 15 to 45 minutes after sunset, and crickets scavenge for carrion at distances up to 30 m from the entrance. Crickets will

occasionally feed on rich fruits, such as Texas Persimmon, or fungi. Adult crickets are more sensitive to light and cold than are nymphs, and on chilly evenings only the nymphs will venture outside. There is a large, annual crop of young crickets. Intense competition occurs at bait stations with the red imported fire ant *Solenopsis (Solenopsis) invicta* Buren. Fire ants invade Texas caves during the spring and summer, where they forage for water and attack cave crickets and other native fauna. These invaders threaten native soil and cave communities, which include endangered species. Several species of *Rhadine* beetles specialize in sniffing out and digging up cave cricket eggs laid in the cave.

THE CRYSTAL BEACH SPRING ECOSYSTEM

Michael K. Garman, 1243 Little John Ln., Dunedin, Florida 34698

The Crystal Beach Spring is a freshwater spring located in the Gulf of Mexico, approximately 300 m offshore from the community of Crystal Beach, Florida. The system is subject to tidal influences as the discharge may reach 280 L/sec at low tide and saltwater from the Gulf may siphon into the system at high tide. The cave system's fauna include five troglobitic crustaceans (two crayfish, *Procambarus* sp. and *Troglocambarus* sp., two amphipods, *Crangonyx hobbsi* and *Crangonyx grandimanus*, and an isopod, *Caecidotea* sp.), two species of mussels, a hydrobiid snail, a hydroid, *Eudendrium cf. carneum*, and several types of bacteria. The crustaceans are throughout the explored freshwater areas of the cave, including areas inundated by saltwater at high tide. The hydroid is only found within the part of the cave that is inundated by saltwater on a regular basis (a penetration of 580m and less). This may indicate that the hydroid depends on plankton brought into the cave system by the saltwater for a food source. The mussels are only found downstream from the Dragons Lair Tunnel. The Dragons Lair contains a distinct halocline/thermocline with freshwater flowing toward the cave entrance on top of stagnant saltwater. Orange bacteria colonies are in the saltwater and a white bacterial "cloud" sits on top of the interface. Bacteria identifications are currently in progress, but it appears that the bacteria in the Dragons Lair generate nutrients on which the mussels are dependent for a food source.

CHANGING INDIANA BAT SUMMER HABITAT AND DECLINING POPULATIONS

Adrienne S. Nold and Timothy Haithcoat, Department of Geography & Ronald Drobney, Fisheries and Wildlife, Internet: c523692@showme.missouri.edu.

The Indiana bat is in much of the eastern half of the United States, with large hibernating populations in Indiana, Kentucky and Missouri. An endangered species, its population is declining rapidly. The decline of this species is most prominent in Missouri, while population numbers are stable to increasing in Indiana. In Missouri, the Indiana bat overwinters in caves in the southern portion of the state, and spends its summers in forested riparian zones north of the Missouri River. Based on previous research, it does not appear that the decline of the species is due to perturbation while overwintering. If the Missouri population continues to decline at the present rate, it is estimated that the Indiana bat will become extinct in Missouri by the year 2023.

DIGGING SESSION

HELICTITE CAVE, VIRGINIA

Philip Lucas, 4411 Fallen Oak Drive, Chantilly, VA 20151-2432

On March 16, 1996, a Virginia Cave was opened after several

years of digging in the bottom of a surface fissure in the Burnsville Cove. The fissure walls contain so many chert stringers and pockets that it is not readily recognizable as limestone. There were two digs in the bottom of the 5.5 m deep fissure that encountered cave passage. The first dig yielded about 120 m of cave passage but was choked with breakdown in the direction that would lead back into the hillside. The second and more extensive digging project, on the uphill side of the fissure and three meters from the first, reached a depth of 7.3 m before breakthrough was achieved.

GEOLOGY AND GEOGRAPHY SESSION

GEOMORPHOLOGY OF FOUNTAIN CAVE, A PSEUDOKARSTIC SINKING STREAM SYSTEM AT ST. PAUL, MINNESOTA

Greg Brick, Department of Geology & Geophysics, University of Connecticut, Storrs, CT 06269

Fountain Cave is the longest natural sandstone cave (350 m) in Minnesota. During headward retreat of the falls of Glacial River Warren, which carved a segment of the Mississippi River gorge at St. Paul, Minnesota, the Platteville Formation's limestone caprock of the river terrace was fractured over the future site of the cave, allowing enhanced recharge to the underlying St. Peter sandstone at this point. The gorge provided a lower base-level, initiating piping along joints in the loosely consolidated sandstone. A tubular void propagated from the wall of the gorge toward the recharge point. The existence of rooms in the cave, which successively decrease in size upstream, suggests tributary piping at joint intersections. Collapse of the cave roof later created a ravine at the cave entrance. In historical times, a surface stream entered a sinkhole on the terrace and flowed through the cave and ravine to the river. The stream allowed the cave to remain open into postglacial times, whereas other sandstone caves in the gorge, without streams, sealed themselves. When expansion of the city of St. Paul dried up the surface stream, early in the present century, Fountain Cave, too, sealed itself.

MICROORGANISMS AND CONDENSATION CORROSION: A DISCUSSION OF DOLOMITE, ITS OCCURRENCE IN CAVES, AND POSSIBLE MICROBIAL MEDIATION

Annette Summers Engel, Department of Geology, University of Cincinnati, Cincinnati, Ohio 45221-0013

Condensation corrosion is the preferential dissolution of a cave by aggressive condensate, controlled by three conditions: a high carbon dioxide concentration, a high air humidity, and a strong thermal gradient between cave passage levels. In Movile Cave, located in Southern Dobrogea, Romania, these conditions are met. Condensation corrosion, occurring in the upper level of the Movile, is linked closely to sulfuric acid speleogenesis in the lower level of the cave. While the bedrock in the vicinity of Movile Cave is limestone with high-magnesium calcite, the corroded rock walls in the cave have been dolomitized. Dolomitization is most evident at the surface of the corroded walls and corrosion residues. Microbes are found in abundance on and around dolomite crystals. Although corrosion residues in Lechuguilla Cave, New Mexico, are thought to be associated with biogenic processes, condensation corrosion is not active in Lechuguilla. Therefore, an opportunity exists to study the active corrosion, bacteria, and dolomite of the Movile. Although dolomite forms from a variety of inorganic mechanisms, this work proposes that the presence of microbes may not only contribute to dolomite formation, but might also accelerate and stabilize rates of mineral precipitation. The metabolic and biogeochemical processes of the bacteria, coupled with possible redox reactions in the condensation pore

waters, all may work to enhance rock dolomitization.

TUMULUS, LAVA TUBE, LAVA RISE, FLOW LOBE, AND DRAIN CAVES OF KILAUEA VOLCANO

William R. Halliday, Hawaii Speleological Survey of the NSS, 6530 Cornwall Court, Nashville, TN 37205

As a result of increasing cooperation between volcanologists and speleologists in Hawaii, the origins of certain puzzling caves of Kilauea Volcano now are better understood. In addition to classical lava tube caves and hollow tumuli, subsidence caves have been identified beneath and adjacent to boundary ridges of lava rises, and of flow lobes with sagged centers. At least two major caves underlie long, sinuous tumuli, and several caves contain remnants of horizontal and/or vertical partitions between drained flow lobes in sheet flows of fluid basalts. The longest cave found in the crater to date (about 500 m) is a two-level complex of drained flow lobes. Also, a single vertical drain cave has been found beneath the sunken center of a prominent lava rise.

CLASSIFICATION AND MORPHOLOGY OF ST. PETER SANDSTONE PIPING CAVES IN MINNESOTA

Greg Brick, Department of Geology & Geophysics, University of Connecticut, Storrs, CT 06269

Piping caves result from mechanical erosion by water in poorly consolidated clastic materials. Hitherto, all natural caves formed by this process in the St. Peter Sandstone, an Ordovician cratonic sheet sand of the Upper Mississippi Valley, have been lumped together as "piping caves," with no attempt made to distinguish among them. But in the state of Minnesota, at least, these caves fall into two distinct populations, tubular and maze caves. The tubular caves are single conduits up to 350 meters in length, wholly within the sandstone. They are graded to nearby river valleys to which they drain(ed). Among named caves, examples are Fountain, Carvers, Old Soldier, and Channel Rock Cavern. The maze caves are low, wide spaces with sandstone pillars supporting a ceiling formed by the base of the overlying Platteville limestone. These voids are related to the St. Peter-Platteville contact. Examples are Farmers & Mechanics Bank Cave, which underlies a whole city block in downtown Minneapolis, and Chutes Cave.

THE FORGOTTEN KARST OF NORTHEASTERN KENTUCKY: A MODEL FOR REGIONAL SPELEOGENESIS, CARTER COUNTY, KENTUCKY

Annette Summers Engel, University of Cincinnati, Department of Geology, Cincinnati, Ohio 45221-0013 & Scott Engel, Dames and Moore, Inc., 644 Linn Street, Suite 501, Cincinnati, Ohio 45203

While numerous cave studies detail the features of large karst terrains, we suggest cavers and researchers not overlook smaller, but no less interesting, karst landscapes. Such a mecca exists in and around Carter Caves State Resort Park, Carter County, Kentucky. Previous attention has been given to the overlying coal-bearing, Pennsylvanian sandstones and to the sedimentology of the Mississippian, Newman Formation carbonates. However, the existing cave systems and their speleogenesis have been virtually ignored. These caves, when observed collectively, provide an excellent tool for regional speleogenetic and geomorphic interpretation. Based on observations in the multiple cave systems and drainage basins, we have developed a model of regional speleogenesis which incorporates three distinct phases. First, phreatic tube development initiated during a time when regional base level was still at elevations above the carbonate units. Second, surface streams cut through the sandstone and into the Newman Limestone, allowing for rapid down-cutting and lowering of

regional base level. During this time, extensive vadose passage development, characterized by high, narrow canyons, occurred in caves throughout the region. Third, major streams quickly cut through the limestone units and into the underlying shale and sandstone of the Bordon Formation. Consequently, the lowest cave passages have lower gradients and greater horizontal passage development.

THE EFFECT OF STREAM PIRACY IN THE DELINEATION OF THE DOLAN SPRINGS DRAINAGE BASIN, VAL VERDE COUNTY, TEXAS

George Veni, George Veni & Associates, 11304 Candle Park, San Antonio, TX 78249-4421, gveni@flash.net

The Dolan Springs Group, located in the western Edwards Plateau in Val Verde County, Texas, is comprised of seven springs within a 1.8-km-radius upstream of the confluence of the Devils River and Dolan Creek. Mean discharge of the individual springs ranges from 101-235 L/s. Some hydrologic inconsistencies are apparent upon initial examination: the springs' drainage basin, as estimated by geochemical calculations, is 30% larger than the area determined by potentiometric mapping; water budget data for the potentiometric basin indicate a mean aquifer recharge rate double that of the surrounding area; and the springs' sustained baseflow does not correlate to the low storage capacity of the limestone. These anomalies result from the subsurface piracy of streamflow from the Devils River for 30 km to the springs. Potentiometric mapping partially supports this hypothesis; more data points are needed south of the river for greater certainty. The piracy is strongly supported by the increase of total dissolved solids in groundwater with distance from the river and increased proximity to the springs, and also by spring hydrographs which show little response to local rainfall but rapid response to the river's discharge. Most of the groundwater flows along the honey-combed contact of the Segovia and Ft. Terrett members of the Edwards Limestone. The lack of local significant cave development suggests the current flow regime is a relatively recent phenomenon along the contact, but the presence of at least one higher elevation and hydrologically abandoned cave may suggest the piracy pre-dates the modern springs.

MAGNITUDE/FREQUENCY ANALYSIS OF CAVE PASSAGE DEVELOPMENT IN THE CENTRAL KENTUCKY KARST

Joe Meiman, Division of Science and Resource Management, Mammoth Cave National Park Mammoth Cave, KY 42259 & Chris Groves, Center for Cave and Karst Studies, Department of Geography and Geology, Western Kentucky University, Bowling Green, KY 42101

A quantitative evaluation of passage growth rates by dissolution has been undertaken within the Logsdon-Hawkins River of Mammoth Cave, Kentucky. Sampling and high resolution monitoring of chemical and flow conditions in the river through two 145m deep wells has allowed an estimate of passage growth during the warm-season months (May-October) of 1995. The surface area of water-wall contact in the passage cross section at the site was determined using stage data, and mineral dissolution rates were estimated using chemical data and several existing dissolution rate expressions, assuming reaction-limited kinetics. During the study period, storm events clearly dominated overall passage growth, with an estimated 70% of the dissolution occurring during the 7% of the time during which the cave was flooded completely to the ceiling. A single storm was responsible for nearly 30% of total passage growth during the 165 days of the study. Different kinetic rate laws resulted in similar relationships between stage and dissolution work, but different estimates of the total work done. Although the impact of siliceous sediment covering

the floor and walls was not quantitatively evaluated, the presumed inhibition of dissolution by this sediment would additionally favor the large events, during which river waters are in contact with the relatively sediment-free rock of the cave ceiling. Further work is underway at the site to evaluate the impact of sediment masking, abrasion by suspended load, and our assumption of an independence between dissolution rates and water velocity which occurs with reaction-limited kinetics.

MECHANICS OF CLASTIC SEDIMENT TRANSPORT IN KARST

Rachel Bosch & William B. White, Department of Geosciences, The Pennsylvania State University, University Park, PA 16802

Most caves contain a suite of clastic sediments ranging from varved clays to cobbles and boulders. In active stream passages, the clastic sediments move mainly under flood flow conditions. If the mechanism of sediment transport were understood, the transport model could be applied to sediment deposits in fossil passages as a means of interpreting past flow conditions. Sediment transport mechanisms also have implications for soil piping and resulting sinkhole formation, and for transport of solid waste and pollutants that have an affinity for siliclastic sediments. Sediment transport theory for surface streams is well developed but its transfer to karst conduit systems is complicated by multiple inputs for water and sediment and by the presence of both pipe and channel flow regimes. Elevation differences between sinking streams and springs give an overall hydraulic gradient from which to estimate the energy line through the aquifer system. Sediment particle sizes are used to estimate boundary shear and therefore stream power. Two thresholds in boundary shear stress occur. The first is the shear stress needed to move sediment as bedload. Bedload movement is strongly a function of particle size, resulting in winnowing and differentiation of sediments. The second threshold is the shear stress required for complete entrainment of the sediment mass resulting in passage flushing and deposition of undifferentiated sediment deposits.

BIOEROSION NOTCHES VERSUS FLANK MARGIN CAVES: VIABILITY AS PALEO SEA LEVEL INDICATORS

Stephanie M. Carney, Department of Geosciences, Mississippi State University, Mississippi State, MS 39762, John E. Mylroie, Department of Geosciences, Mississippi State University, Mississippi State, MS 39762, & James L. Carew, Department of Geology, University of Charleston, Charleston, SC 29424

Recently, dramatic claims have been made regarding sea level conditions during the last interglacial sea level highstand (oxygen isotope substage 5e), based on the position of features interpreted to be fossil bioerosion notches in the Bahama islands. We believe that those interpretations are questionable, as the features described as fossil bioerosion notches may in fact be the eroded remnants of flank margin caves. The distinction is critical, as flank margin caves take much longer to develop than do bioerosion notches, and would require sea level to have been at +6 m for substantially longer than the <1,000 years that has been proposed. Flank margin caves are commonly found with all or portions of their outer wall removed by surficial erosion; this erosion is more than enough to remove fossil bioerosion notches. Erosion rates for Quaternary limestones quoted in the literature indicate a minimum denudation rate of 4 m/100 Ka, which is enough to have removed fossil bioerosion notches and breached into flank margin caves contained within a hillside. A preliminary comparison of eroded flank margin caves and modern bioerosion notches on San Salvador Island, Bahamas, indicates that morphological analysis can distinguish between fossil bioerosion notches and highly-erod-

ed flank margin caves. This comparison showed that eroded flank margin caves typically contain phreatic dissolutional surfaces, speleothems, and have undulating floors and ceilings. On the other hand, modern bioerosion notches have very flat ceilings and floors at a consistent elevation, and evidence of bioerosion activity. As bioerosion notches form at the surface environment, fossil notches would not contain dense calcite speleothems.

THE FRESHWATER/SALTWATER MIXING ZONE IN THE WAYNES WORLD SINK CAVE SYSTEM

K. Michael Garman, 1243 Little John Lane, Dunedin, Florida 34698, cavebear@gte.net

Waynes World Sink is located in Hudson, Florida. The Sink is approximately 450m (1500 ft) east of the head of Cow Creek (a saltwater, tide influenced creek) and approximately 900m (3000 ft) east of the Gulf of Mexico. The Sink leads to a complex, submerged, anchialine cave system primarily developed at a depth of ~30m (90 to 100 ft). The water in the cave system is usually brackish with a permanent halocline above a 43m (140-ft) deep saltwater tunnel. The deep saltwater tunnel is approximately 120m (400 ft) long and another brackish water tunnel is found at its opposite end. The Sink is tide-influenced. The Main Street Tunnel, which trends southwest toward the Gulf, is a strong siphon toward the Gulf at low tide and a strong spring inland at high tide. At low tide, a groundwater divide is created within the cave system with some water flowing toward the Gulf through the Main Street Tunnel and some water flowing toward a nearby spring. The complex interactions between brackish and saltwater in this cave system have created a unique environment where troglobitic crustaceans (crayfish, *Procambarus leithuseri*, and isopod, *Caecidotea* sp.), which are generally considered freshwater organisms, are found in the same location as anemones and feather duster worms. The cave system environment has also changed significantly during the study period from February 1996 to January 1997, as below normal rainfall has caused the salinity in the system to increase from less than 5 parts per thousand to 15 parts per thousand.

PRELIMINARY RESULTS OF SPELEOTHEM U/Th DATING FROM THE HELDERBERG PLATEAU, NEW YORK

Stein-Erik Lauritzen, Department of Geology, University of Bergen, N-5007 Bergen, Norway & John E. Mylroie, Department of Geosciences, Mississippi State University, Mississippi State, MS 39762

The Helderberg Plateau consists of gently dipping Silurian-Devonian carbonates that outcrop across central New York state, supporting a well-developed, multiply-glaciated karst. Stalagmites and flowstone collected from five caves covering a 60 km Plateau traverse, WNW from Albany to Schoharie County, yielded 36 U/Th alpha count dates. Hollyhock Hollow, southern Albany County: two cave-fill samples yielded three dates of 56-70 Ka and four dates of 35-41 Ka. The mid-Wisconsin dates may reflect the cave's southerly position. Onesquethaw Cave, central Albany County: two stalagmites yielded five dates, all Holocene (<9 Ka) in age. The dates suggest that Onesquethaw Cave may be post-glacial in origin. Caboose Cave, eastern Schoharie County: five stalagmite and flowstone samples provided 13 dates, ranging from 56-207 Ka, with distinct clusters at 56-100 Ka and 172-207 Ka. The dates support the cave being older than the last glaciation. Schoharie Caverns, two km west of Caboose Cave: six samples from one flowstone all dated to >350 Ka. The dates indicate that the cave has survived more than one glaciation. Barrack Zourie Cave, western Schoharie County: two stalagmites yielded four dates, which cluster at 158-161 Ka, with a younger overgrowth at 61

Ka. Two previously reported dates were 165 Ka and 277 Ka. The dates support the cave being older than the last glaciation. The U/Th dates indicate that both pre- and post-glacial caves exist in New York. The dates cluster in the 56-100 Ka and 158-207 Ka range, and there are a surprising lack of dates from the last interglacial (120-130 Ka), possibly an artifact of the sampling regime.

TRAVERTINE DEPOSITION FROM HIGH-SULFATE SPRING WATER: A CLUE FOR SECONDARY POROSITY DEVELOPMENT BY DEDOLOMITIZATION
Penny M. Taylor, Department Earth Sciences, SUNY College at Oneonta, Oneonta, NY, 13820, taylp12@oneonta.edu

High-sulfate springs are the source of several travertine-depositing streams in central New York. Water chemistry of springs was compared and rates of travertine deposition were measured using artificial substrates. Water samples from springs were analyzed for major ions. Diffuse seeps through glacial sediment allow equilibrium adjustments prior to sample collection. Springs were at or above saturation with calcite. Gypsum equilibrium was variable, with the only saturated samples coming from an artesian well. Degassing of H₂S and lack of dissolved O₂ at the well suggest deep circulation of meteoric waters through a reducing environment. An iterative program was used to calculate chemical equilibria, interpret sources of dissolved components and create flow-path models. Models were used to determine mineral solubility for solutions including calcite, dolomite and gypsum. Results indicate decreasing calcite solubility and increasing solubility for dolomite and gypsum when they are in solution together. Decreased calcite solubility and potential calcite precipitation are due to the common ion effect as additional minerals are dissolved. Increased solubility of dolomite and gypsum (1.5 times and 3.7 times individual mineral solubilities respectively) increases secondary porosity within the aquifer. Based on chemical analysis and the results of modeling with the computer program. This study area provides a good field example for the diagenetic process of dedolomitization. Travertine deposition occurs where CO₂ degasses abruptly from calcite-supersaturated water.

PHOSPHATE MINERALOGY OF ISLA DE MONA CAVES
William B. White, Department of Geosciences, The Pennsylvania State University, University Park, PA 16802 & Joseph W. Troester, U.S. Geological Survey, 651 Federal Drive, Suite 400-15, Guaynabo, PR 00965-5703

Isla de Mona is a 55-km² island lying in the Mona Passage between Puerto Rico and the Dominican Republic. Large complex caves, with numerous entrances along the sea cliffs that bound Isla de Mona, extend along the island margin, often for 1,000 m or more, becoming smaller inland, ending within 250 m of the cliff face. Within the caves are thick phosphate deposits which were mined extensively in the late 18th Century. Phosphate minerals were sampled mainly from Cueva de Aleman and Cueva Lirio and characterized by x-ray diffraction, infrared spectroscopy, and scanning electron microscopy. The dominant minerals are brushite, CaHPO₄ · 2H₂O; hydroxyapatite Ca₅(PO₄)₃(OH); and gypsum. Other minerals reported included monetite, CaHPO₄ (the mineral is named for Isla de Mona); whitlockite, Ca₃(PO₄)₂; and crandallite, a complex Ca-Al phosphate. At least three additional minerals occur in the phosphate deposits from these two caves. In a distinctly layered 30-cm section of phosphate minerals in Cueva de Aleman, brushite dominates at the top and decreases toward the bottom as hydroxyapatite increases to become the dominant mineral.

EVALUATION OF THE HYDROLOGIC AND GEOMORPHIC CHARACTERISTICS OF THE WARRENSBURG ROAD KARST, DELAWARE COUNTY, OHIO.

T. Joseph Dogwiler, Department of Geosciences, Mississippi State University, Mississippi State, MS 39762 & Horton H. Hobbs III, Department of Biology, Wittenberg University, Springfield, OH 45501

The Warrensburg Road Karst, Delaware County, Ohio, is characterized by numerous insurgent stream sinks, a subterranean drainage system, and a resurgent spring. This 1.75 km² karst drainage basin is representative of the karst developed in the Columbus Limestone in the mostly agricultural western portion of Delaware County. As the suburban fringe advances north from Columbus, Ohio, these hydrologic systems require investigation in order to assess potential environmental, engineering, and land use impacts associated with residential/commercial development. Furthermore, continued agricultural usage requires an understanding of the karst system to enable mitigation of future soil loss. The purpose of this study was to establish a baseline data set that includes the size and hydrologic and geomorphic characteristics of the drainage basin for the resurgent spring in order to facilitate future research. Fluorescein dye tracing was utilized to establish the hydrologic connections between the numerous sinking streams in the area and the resurgent spring. The boundaries of the drainage basin were delineated based upon the topographic catchment of the insurgent streams. Five major insurgences to the subterranean drainage system were identified and found to contribute 50-70% of the water discharged at the resurgent spring during storm events. The balance of the discharge is most likely derived from numerous small, sinkhole inputs and groundwater baseflow. Additionally, channel bed scour and deposition were evaluated within the sinking streams. Net scour rates of 12-76 mm were observed during April and May 1995, suggesting that large amounts of sediment are transported through the subterranean drainage system.

GLADEVILLE UTILITY DISTRICT WELLHEAD PROTECTION PROJECT: USE OF FLUORESCENT DYES TO DETERMINE THE GROUNDWATER ZONE OF CONTRIBUTION TO A PUBLIC WATER SUPPLY SOURCE

Eric Anderson, 648 Des Moines Dr., Hermitage, TN 37076, anderson@telalink.net & Philip Rykwald, 632 Atlanta Dr., Hermitage, TN 37076

The Gladeville Utility District (GVUD) is a public water supply system servicing over 10,000 people in southern Wilson County, Tennessee. The GVUD is located in a maturely developed karst terrane and utilizes two wells as a raw water source. The purpose of this project was to define the surface and groundwater area of contribution for the GVUD as a tool for management of this important resource. The hydraulic boundary of the GVUD was identified from topographic and geologic maps as well as field reconnaissance. Initially, the basin boundaries were monitored for the presence of background concentrations of dye. Quantitative and qualitative tracer tests were then performed using low concentrations of fluorescent dyes to confirm the basin boundaries and to estimate the time-of-travel for surface water and groundwater in the system. With the data collected from the tracer tests, the area of contribution for the basin was estimated to be 150 km. Further tracer testing is necessary to better define the northern and western boundaries of the basin. Results of the tracer tests showed the direct connection between surface streams, groundwater, and the raw water source for the GVUD. Results of quantitative testing to the GVUD indicated groundwater velocities as great as 443 m per hour. The area of contribution and groundwater velocities provide critical information for predicting the potential impacts on the GVUD from commercial and residential development and for planning response to a possible hazardous materials release.

A SAMPLING PLAN FOR CONDUIT-FLOW KARST SPRINGS: MINIMIZING SAMPLING COST AND MAXIMIZING STATISTICAL UTILITY

James C. Currens, Kentucky Geological Survey, University of Kentucky, 228 Mining and Mineral Resources Bldg., Lexington, KY 40506-0107, currens@fido.mm.uky.edu

Analytical data for nitrate and triazines from 566 samples collected over a 3 year period at Pleasant Grove Spring, Logan County, KY, were statistically analyzed to determine the minimum data set needed to calculate meaningful yearly averages for a conduit-flow karst spring. Results indicate that a biweekly sampling schedule augmented with bihourly samples from high-flow events will provide meaningful suspended-constituent and dissolved-constituent statistics. Unless collected over an extensive period of time, daily samples may not be representative and may also be autocorrelated. All high-flow events resulting in a significant deflection of a constituent from base-line concentrations should be sampled. Either the geometric mean or the flow-weighted average of the suspended constituents should be used. If automatic samplers are used, then they may be programmed to collect storm samples as frequently as every few minutes to provide detail on the arrival time of constituents of interest. However, only samples collected bihourly should be used to calculate averages. By adopting a biweekly sampling schedule augmented with high-flow samples, the need to continuously monitor discharge, or to search for and analyze existing data to custom design a statistically valid monitoring plan is lessened.

THE USE OF DISCHARGE BALANCING TO QUANTIFY THE ASSIMILATIVE CAPACITY OF A KARST AQUIFER: AN IMPORTANT TOOL IN PREDICTING CONTAMINANT CONCENTRATIONS AT A SPRING AND FOR DECISION MAKING FOR REMEDIATION OF ENVIRONMENTAL PROBLEMS IN KARST

Geary Schindel, Eckenfelder Inc., 227 French Landing Drive, Nashville, TN 37228, Dan Lovingood, 301 Gallaher View Road, Suite 227, Knoxville, TN 37923 & Steve Worthington, McMaster University, Hamilton, Ontario, L8S 4K1

A tracer test investigation was performed by the U.S. Environmental Protection Agency (EPA) to delineate the groundwater drainage basins of an industrial area located on Ordovician carbonate rocks in the Central Basin of Tennessee. This area had been the focus of state and U.S. EPA investigations and response actions since the early 1980s. Based on the results of the tracer test, and by using the concepts of discharge balancing from Quinlan and Ray (1995), the percent contribution of groundwater discharging from a karst spring was determined for a site with a surface area that is a fraction of the total footprint of the groundwater basin. This was calculated by dividing the two dimensional area of the site by the two dimensional area of the groundwater basin. Soil response action levels for site related constituents were then calculated by dividing the product of each constituent's surface water criterion and its corresponding soil-water partitioning coefficient (Kd) by the estimated percentage of water contribution to the karst spring from the site. The calculations were also used to quantify the assimilative capacity of the carbonate aquifer for this industrial area. Soils with constituent concentrations that exceeded the soil response action levels were removed during the last and final response action. Monitoring of the spring before, during, and after a storm event by the U.S. EPA indicated that the water quality parameters were not exceeded. The State of Tennessee issued a "no action" Record of Decision for the Site.

THE STRUCTURAL FEATURES OF KARST CAVES AND GEOMORPHOLOGY IN PINGBA COUNTY, ANSHUN, GUIZHOU PROVINCE, CHINA

Jiang Xinrong, Geography Department, Guizhou Normal University

Pingba County, Anshun, is located at the center of Guizhou Province, China. The geomorphology of the karst plateaus and canyons are classic and quite apparent. The plateau region lies in the upper course and the watershed area. The difference in elevation is less than 200 m. Geomorphologically, the area exhibits typical fenglin (isolated peaks), basins (polje,) and fenglin valleys. The river valley is wide and the terraces are well developed. The river gradient is normally less than 2%, and the water table gradient is 0 to 20 m beneath the surface. The surface slope gradient is 1-3%. The caves in the study area consist of relic caves within the plateau fenglin. The canyon zone is distributed in the middle and lower course of the drainage area. The elevation change is large and ranges from 200 to 500 m. The major geomorphic types are fengchong-canyon (isolated peaks and canyon,) and fengchong-depression (isolated peaks and depressions). The river valley is mainly canyon and gorge. The hydraulic gradient of the river in this area is more than 6%, and the subsurface water lies from 80-200 m below the surface, with its hydraulic gradient ranging from 7-20%. The caves in the study area have developed from canyon rejuvenation.

PRELIMINARY RESEARCH ON THE DEVELOPMENT OF A MATHEMATICAL MODEL OF KARST CANYONS: A CASE STUDY OF THE MIAOTIAO AND LIUCHONG RIVERS, CHINA

Xiao Honglin, Geography Department, Guizhou Normal University

Karst canyons belong to a special geomorphologic type which develop by combined river erosion, corrosion, and collapse processes. Their genesis and development are closely related to properties of the rock they are formed in, the hydraulic gradient of the river bed, and the discharge of the river cutting the canyon. Karst canyons and their specific features have very significant effects on local and regional projects concerning water conservation, soil erosion control, and hydroelectric power stations.

GEOLOGIC SETTING OF CUEVA DE VILLA LUZ - A RECONNAISSANCE STUDY OF AN ACTIVE SULFUR SPRING CAVE

Louise D. Hose, Department of Environmental Studies, Westminster College, Fulton, MO 65251 and James A. Pisorowicz, Wind Cave National Park, Hot Springs, SD 57747

At least eight risings of thermal, sulfur-rich waters flow into an actively forming, currently air-filled cave in Tabasco, Mexico. Cueva de Villa Luz (aka Cueva de la Sardina) is located two kilometers south of the town of Tapijulapa in a small block of Lower Cretaceous limestone, which a federal geologic map shows as a northwest-trending anticline truncated and uplifted on the south by an east-northeast-trending normal fault. The resurgence entrance to the northeast-trending cave is along this fault. Also along this fault are at least six other smaller sulfur-rich springs. pH levels of the rising water both within the cave and on the surface were 6.9 - 7.0 (+/-0.5). The cave stream had values ranging from 7.2 upstream, near the risings, to 7.4 at the resurgence. Water drops from the ubiquitous "snotthems" displayed pH values of 0.5 to 3.0(+/-0.5). All water temperatures were 28°C in late December 1996 and early January 1997. Previous analyses of native sulfur and gypsum deposits in the cave determined light $d^{34}S$ values of -22.12 to 26.60 (Spirakis & Cunningham, 1991) and suggest a biological role in fixing the sulfur. However, the original source of the sulfur is unknown. The cave is 65 km from Villahermosa, which suggest a possible migration of hydrogen sulfide from petroleum reservoirs. However, the cave is also only 10 km from a Tertiary andesitic flow and 50 km from the recently erupted Volcan el Chichonal, which has sulfur-rich waters in its caldera.

HISTORY SESSION

ILLINOIS CAVERNS, PRIDE OF THE ILLINOIS UNDERGROUND *Joe Walsh, 2805 Williams Creek Road, Fenton, MO 63049*

Previously known as Eckert Cave, Egyptian Caverns, Burksville Cave, Little Mammoth, and Mammoth Cave of Illinois, this cave remains the best known and most historic of all the caves in Illinois. The cave has probably been known since at least 1795. In 1901, the cave was proclaimed one of the "great wonders of the world" in an article that appeared in the St. Louis Post Dispatch. It was featured as part of the St. Louis World's Fair. Following the World's Fair, Charles White launched an unsuccessful attempt to commercialize the cave, and it was soon forgotten. Armin Krueger was one of the locals who actively explored the cave during the next thirty years. In the early 1940s, William Hayden attempted to commercialize the cave once more, installing electric lighting and a concrete stairway down into the cave. World War II intervened, and gasoline rationing soon speeded the end of this venture as well. Illinois Caverns once again became a "wild" cave, and was operated by Armin as caretaker until his death in August 1996. The cave now belongs to the Illinois Department of Conservation. It continues to be open to caving as of this writing. Few caves in this writer's experience are as well known and beloved as this beautiful cavern beneath the picturesque agricultural landscape of southern Illinois.

IDENTIFICATION OF KENNETH EMORY'S MYSTERIOUS "HERBERT C. SHIPMAN CAVE", PUNA DISTRICT, HAWAII COUNTY, HAWAII *Kevin Allred, Stephan Kempe, & William R. Halliday, Hawaii Speleological Survey of the NSS*

In 1945, the great Bishop Museum staff archaeologist, Kenneth Emory, prepared a typescript report on what he called "Herbert C. Shipman Cave", located about 20 km from Hilo, HI. With increasing urbanization, repeated reference to this cave appears in archaeological sections of Environmental Impact Statements, but all are based solely on Emory's typescript. Until recently, no archaeologist or speleologist is known to have located Emory's cave. Recent studies by Hawaii Speleological Survey teams have shown that Emory was in two different caves in two different lava flows. Use of the name "Herbert C. Shipman Cave" or the abbreviated form "Shipman Cave" should be terminated, and the names of the individual caves should be used instead.

EARLY MIDWESTERN SHOW CAVES IN MINNESOTA *Greg Brick, Department of Geology & Geophysics, University of Connecticut, Storrs, CT 06269*

Until recently, it was assumed that no Minnesota show caves predated the 20th Century. Research indicates, however, that Minnesota had two of the earliest show caves in the Midwest, Fountain Cave and Chutes Cave. Both were located in an urban area, thus explaining how they were able to exist so much earlier than the state's rural show caves, which had to wait upon development of the automobile, and also why their existence was short: loss of scenic values due to encroaching urbanization. Fountain Cave (1852-1857), often claimed to be the birthplace of St Paul, MN, is featured in old travel guides. Near the cave there was a shanty, where, for a consideration, the visitor could obtain a guide and a tallow candle. The highlight of the tour was a room called Cascade Parlor, which contained a waterfall, but there were no speleothems in this sandstone cave. The cave is no longer accessible, having been buried during highway construction in 1960. Chutes Cave (1875-1883), in Minneapolis, was discovered in 1864 during the excavation of a power tunnel. Advertised in newspa-

pers, ten cents purchased a ride in a boat with a flaming torch at the bow, floating more than 150 m through the abandoned tunnel and into the natural cave. It remains the most profusely decorated cave in this part of the state, containing a flowstone-coated breakdown pile called the "Tower of St. Anthony."

AN INTRIGUING 1925 SKETCH MAP OF FLINT RIDGE *William R. Halliday, 650 Cornwall Court, Nashville, TN. 37025*

In 1925 the Chicago Tribune published a sketch map of "the great cave system underlying the entire region in the vicinity of Mammoth Cave, in Kentucky" in its coverage of the tragedy of Sand Cave. Some parts of it are ludicrous but other parts may have been based on actual exploration. Identity of the artist is unknown, but some deductions can be drawn from its contents. Location of an "Entrance #2" to Sand Cave suggests a focus for ridgewalking.

THE MYSTERIOUS MISS RUTH HOPPIN *Jo Schaper, 46 Cedar Dr., Pacific, MO 63069, joschaper@aol.com*

Ruth Hoppin is credited with the discovery of the Ozark cavefish (*Amblyopsis rosae*), the bristly cave crayfish (*Cambarus setosus* Faxon) and an isopod, the only one of three to be given her name—*Asellus hoppinae*. The woman, herself, has been quite a mystery, however, with much of what we know of her being derived from an 1889 article in the Bulletin of Comparative Zoology, *Cave Animals from Southwestern Missouri*, by Samuel Garman of Harvard. This spring, in connection with the purchase of Sarcoxie Cave, (aka Days Cave) in Jasper County, Missouri, Jan Hinsey of the Ozark Regional Land Trust unearthed a treasure trove of biographical information on Miss Hoppin, Preceptress of botany at Michigan State Normal School, Ypsilanti, Michigan. Although how she arrived in Jasper County is still a mystery, much light has been shed on the life of this botanist and cave biologist by these accounts.

INTERNATIONAL SESSION

THE 1997 GUNUNG BUDA EXPEDITION TO SARAWAK, MALAYSIA *Joel Despain, P.O. Box 211, Three Rivers, CA 93271 & David Bunnell, 320 Brook Rd., Boulder Creek, CA 95006*

The 1997 Gunung Buda Expedition was another successful attempt to document the caves and karst features of beautiful Gunung Buda (White Mountain) in Sarawak, Malaysia. A total of 25 km of new survey and 1.4 km of re-survey was completed in 17 caves. During the five-week expedition, eight new caves were surveyed (Hornbill, Loris, Babylon, Mojo, Langur, Thunder, Twilight, and Fruit Bat) in Buda and one in nearby Gunung Benarat (Deliverance). Additional survey work was completed in seven caves (Green Cathedral, Snail Shell, Quill, Lower Turtle, Upper Turtle, Sea Breeze, and Biocyclone) that were partially explored in 1995. Perhaps the expedition's most significant event was on February 12 when a team of four connected Green Cathedral and Upper Turtle caves, creating a cave system 24 km in length and over 300 m deep. Deliverance, Thunder and Hornbill caves feature much larger passages and rooms compared to the caves that had been previously explored in the area. This includes a 200 m diameter room in Deliverance, a 140 m diameter room in Thunder and a passage 30 m by 40 m with an 80 m skylight in Hornbill. Photographic documentation was undertaken in ten caves (Deliverance, Snail Shell, Mojo, Cathedral, Thunder, Biocyclone, Hornbill, Loris, Quill, and Fruit Bat). Members of the team, coordinated by Vivan Loftin, conducted a biological inventory in RolyPoly Cave, and Andrea Futrell collected sediment samples for paleomagnetic dating in several caves. This spectacular limestone

mountain was first visited by British cavers in 1984, and a full scale American/Malaysian Expedition documented 30 km of cave passages here in 1995.

SPELEOLOGICAL POTENTIAL OF KAMCHATKA OBLAST, SIBERIA, RUSSIA
William R. Halliday, Commission on Volcanic Caves of the International Union of Speleology, 6530 Cornwall Court, Nashville, TN 37205

Long the most forbidden, inaccessible part of Russia, Kamchatka suddenly has become its closest caving area to the USA. Two areas of volcanic caves are known. The more important is just south of Tolbachik Volcano, in one of the world's most spectacular volcanic areas. While the longest cave here has only about 0.5 km of passages, there are potentials for much more. The area is nearly inaccessible, and special arrangements must be made for (Red) Army surplus 6-wheel vehicles, at considerable cost.

EXPLORATION AND MAPPING OF CUEVA DE VILLA LUZ (CUEVA DE LA SARDINA), TABASCO, MEXICO

Louise D. Hose, Department of Environmental Studies, Westminster College, Fulton, MO 65251 & James A. Pisarowicz, Wind Cave National Park, Hot Springs, SD 57747

Cueva de Villa Luz near the town of Tapijulapa has been used in indigenous religious ceremony since ancient times. Scientists visited the cave, also known as Cueva del Azufre, in April 1944 and returned in the 1940s and 1950s to study the partially cave-adapted mollies (*Poecilia sphenops*). Cavers, however, only discovered the cave in 1986. An NSS Caves of Tabasco, Mexico, Project expedition last winter completed the mapping of the 1613 m long cave and continued geologic and biologic observations. While the cave's air and water temperature (28°C) are comfortable, measured atmospheric H₂S ranging from 6-32 PPM limited exploration. Water pH measurements from 0.5 to 7.9 also raised interests. The abundance of the 25-55 mm long fish resembles a hatchery throughout the cave, which is also called Cueva de la Sardina. The fish are so crowded that it is easy to catch several in one's hand with a single attempt. They were also observed climbing up a series of rimstone dams looking like salmon climbing their ladders. Each spring, descendants of the Maya speak with their gods in the cave. The Chol ceremony includes scooping up cave fish with baskets and eating them. The cave houses a variety of invertebrates and a large colony of at least three species of bats. Abundant midges may provide a food source to the fish. Samples from the cave's rich microbial community are currently being investigated. Most noteworthy are the "snotthem", which look like small soda straws and curtains made of white mucous.

CHINA CAVE PROJECT; FURTHER EXPLORATIONS OF THE GUADOU SYSTEM, GUIZHOU, CHINA

Ian Baren, China / USA Caves Project, PO Box 541, Katonah, NY 10536 & Don Coons, China/USA Caves Project, RRI, Rutland IL 61358

In the winter of 1994, Bob Cohen and Mike Newsome extended the map of Chuifeng Dong towards its suspected connection with the Doubin Dong upstream river. After setting up an in-cave camp, they descended three drops to the sound of river water, only to be stopped by lack of more rope. In 1995-95, Mike, Bob, Don Coons, Molly Lucier and Ian Baren returned and, with four cavers from Guizhou Normal University, made a connection between the two caves the first day out. After setting a base camp in Doubindong river passage, the team spent 18 days underground, mapping upstream towards a hoped for connection with two insurgence caves to the south, Xiaoludong

and Youcaidong. Both had been explored to sumps in previous expeditions, but there was hope of a bypass. More than four kilometers of passage were mapped, including dry upper levels with many going leads. Rather than a bypass to the two caves to the south, three upstream sumps were discovered. An extensive surface survey was made to tie the entrances of five of the local caves with benchmarks, and water chemistry survey by Professor Xiong Kangning and Don Coons revealed the highly acidic river water which accounts for the impressive size of the caves. True to project tradition, a massive upper level borehole lead was sighted on the last day and headed south.

PALEONTOLOGY SESSION

PLIOCENE CAVE AND FISSURE DEPOSITS IN THE NORTHERN BLACK HILLS OF SOUTH DAKOTA WITH COMMENTS ON THE CARNIVORES

Philip R. Bjork, Museum of Geology, South Dakota School of Mines and Technology, 501 East Saint Joseph Street, Rapid City, SD 57701, pbjork@msmailgw.sdsmt.edu

About eight kilometers northwest of Lead, SD, in a limestone quarry at the Richmond Hill Gold Mine, cave and fissure deposits of Pliocene age are preserved at elevations between 1690-1710 m. Six separate localities within the north and east faces of the quarry high wall have exposures of deposits in caves and fissures in the lower portion of the Pahasapa Formation (Mississippian). The principal sites are the Unwily Coyote Site and East-West Fissure. These deposits are important because they record the existence of caves in the northern Black Hills at least by the Pliocene. Secondly, removal of Tertiary sediments of the White River Group that blanketed the Black Hills uplift must have occurred in this area by Pliocene time. Among the mammals recovered are the taxa *Canis lepophagus*, *Ferinestrix?*, *Mustela*, and cf. *Trigonictis idahoensis*. *Ferinestrix?* is a large mustelid carnivore that is larger than living *Gulo* and North American species of *Plesiogulo*. Three first upper molar teeth representing at least two individuals are present and are distinct from *Plesiogulo*. Front limb elements from the Unwily Coyote Site of *Ferinestrix?* are most similar to *Plesiogulo* among known late Tertiary mustelids. The assignment, *Ferinestrix?*, is tentative because it is based on material not previously recorded for *Ferinestrix* from the Hagerman local fauna.

MAMMOTHUS PRIMIGENIUS FROM ENDLESS CAVERNS: THE FIRST CAVE RECORD OF MAMMOTH FROM VIRGINIA

Frederick Grady, Department of Paleobiology, MRC 121 NHB Smithsonian Institution, Washington, DC 20560, David A. Hubbard, Jr., & Wade Berdeaux

A mammoth tooth found in Endless Caverns, Rockingham County, is a first cave record for Virginia. This is only the fifth locality for *Mammuthus* within the Commonwealth. Differentiation as *Mammuthus primigenius* Blumenbach was made on the basis of size, number of enamel plates, and thickness of the enamel of this lower third permanent molar. The partially exposed tooth was discovered in a sediment bank, during July 1996. Study of the site during removal of this nearly pristine tooth indicated it was deposited by a debris flow through a former entrance. Endless Caverns is developed in the middle Ordovician limestones of a minor anticline on the northwestern flank of Massanutten Mountain, a complex sandstone ridge on the northwest limb of the Massanutten synclorium. The caverns' seven kilometers of passage underlie the transition of the lower forested mountain flank and the adjacent grassland valley. Grassland apparently existed above a portion of the cave at the time this woolly mammoth perished. The rarity of mammoth remains from caves of the

Appalachian Highlands is mirrored by the scarcity of other large grassland grazers of the Pleistocene, such as horse and bison, in cave sites. Although few Virginia cave sites have yielded large extinct taxa, the scarcity of grassland grazers in caves elsewhere in the central and northern Appalachian Highlands implies grassland ecosystems were not extensive.

LATE GLACIAL MOLLUSKS FROM LITTLE BEAVER CAVE, CENTRAL OZARKS, MISSOURI

Jim I. Mead, *Department of Geology, Northern Arizona University, Flagstaff, AZ 86011* & Blaine W. Schubert, *Quaternary Studies, Northern Arizona University, Flagstaff, AZ 86011*

Paleontological excavations at Little Beaver Cave, Phelps County, Missouri, yielded a diverse fauna for the terminal Pleistocene of the Central Ozarks, including extinct, extralimital, and locally extant species. Three AMS radiocarbon determinations, from bone-specific amino acids, provide chronological control for the faunal samples, dating between 10 Ka and 11.5 Ka. The mammalian fauna has been analyzed by Schubert and documents an association of boreal and temperate taxa. The report about the mammals is the first documentation of several boreal species for the terminal Pleistocene Ozarks. This disjunct assemblage may reflect a retention of an equable climate up to the Pleistocene/Holocene boundary. Mollusks were recovered throughout the stratigraphic column containing fish, reptiles, birds, and mammals. Molluscan taxa include: 11 terrestrial gastropods, 4 aquatic gastropods, and 3 clams. All species can be located in the Ozarks today, except for the possible recovery of *Pupoides modicus* (today restricted to Florida). This find is an extralimital anomaly in the faunal assemblage. Previous studies of late Pleistocene mollusks are lacking from the Ozarks, except for a few of the larger taxa. The success in recovering mollusks at Little Beaver Cave was due to wet sieving through fine mesh (0.7 mm) screens. Even the modern malacofauna is inadequately understood for the Ozarks. The terrestrial gastropods indicate a woodlands habitat with abundant leaf litter and some areas of more open grassy lands, such as in a meadow. The aquatic mollusks indicate open bodies of water, such as rivers, lakes and streams; some had to be sluggish and others with more current action.

PALEOECOLOGICAL IMPLICATIONS OF A TERMINAL PLEISTOCENE MAMMALIAN FAUNA, LITTLE BEAVER CAVE, CENTRAL OZARKS, MISSOURI

Blaine W. Schubert, *Quaternary Studies, Northern Arizona University, Flagstaff, AZ 86011*

Previous investigations of late Pleistocene mammalian faunas from the Ozarks are numerous but either lack systematic excavations, temporal control, and/or sufficient micromammal (e.g. voles and shrews) components essential for interpreting the environments of the Pleistocene/Holocene transition. At Little Beaver Cave, three high resolution radiocarbon dates on bone specific amino acids, systematic sampling, fine mesh wet sieving (0.7 mm), and diverse micromammal components provide an ecological basis for interpreting this temporal interval (approximately 11.5 Ka - 10.0 Ka). Extinct species represented are *Megalonyx jeffersonii* (Jefferson's ground sloth), *Mylohyus nasutus* (long-nosed peccary), *Platygonus compressus* (flat-headed peccary), and *Dasyurus bellus* (beautiful armadillo). Of these, only *P. compressus* and *D. bellus* were recovered from controlled samples. Seven extralimital small mammals (1 shrew, 2 squirrels, and 4 voles) were recovered from systematic excavations. *Blarina* cf. *B. brevicauda*, *Spermophilus* cf. *S. tridecemlineatus*, and *Microtus pennsylvanicus* are locally extralimital and suggest open

and moist habitats with some forest cover. *Tamiasciurus* cf. *T. hudsonicus*, *Clethrionomys* cf. *C. gapperi*, *Phenacomys* cf. *P. intermedius*, and *M. xanthognathus* are boreal extralimital taxa and require cool summers and boreal environments. The association of extralimital taxa with current resident species from Little Beaver Cave may reflect a mosaic of coniferous, deciduous, and open habitats during the waning years of the Wisconsinan for the Ozark Highland. A cool and moist equable (less seasonal) climate provides a possible hypothesis for this nonanalogous faunal assemblage. Further, having boreal affinities up to the Pleistocene/Holocene boundary supports a rapid transition into the climatic severity characteristic of the Holocene.

FOSSIL MAMMALS AND MEXICAN CAVES

Joaquin Arroyo-Cabrales & Oscar J. Polace, *Laboratorio de Paleozoología, INAH, Moneda #16, Col. Centro, 06060, Mexico, D. F. Mexico*

During the last decades, the knowledge of the Pleistocene in Mexico increased with the discovery of a large number of localities. A few caves with fossil vertebrate deposits have been known since the last century. In 1867, Weber recorded the finding of mammoth remains in Cueva del Padre, Nuevo Leon. Since then, more than 15 fossiliferous caves have been found, including Cueva de San Josecito, Nuevo Leon; Cueva Encantada de Chimalcatlan, Morelos; Actun Spukil, Actun Lara, and Gruta de Loltun, Yucatan; Monte Flor, and Cueva de San Agustín, Oaxaca; Cueva de las Iglesias, Durango; Cueva del Abra, Tamaulipas; caves of Bustamante and La Mina, Nuevo Leon; Gruta de Cócóna, Tabasco; Cueva de Jimenez, Chihuahua; Cueva la Presita, San Luís Potosí; and, most recently, Mina San Antonio, San Luís Potosí. All but Monte Flor, with findings previously identified as archaeological remains, have been recorded as having animal remains from Late Pleistocene or earliest-Holocene age. Among the 16 caves, only San Josecito, Jimenez, Spukil, Loltun, and La Presita served as natural traps. San Josecito is the best known due to its abundance and diversity of vertebrate taxa. It and Loltun Cave are the only ones systematically excavated, accounting for a detailed stratigraphic record. Among the vertebrate taxa, the mammals are the best known, adding to 256 species, with the small mammals the most abundant, but the large ones the most studied. Excepting Iglesias and Jimenez, all caves are in eastern Mexico, and the analyses and comparisons of the mammal faunas should allow establishment of a zoological framework for the region during the Late Pleistocene.

CHARACTERISTICS AND IMPORTANCE OF CAVE SITES IN QUATERNARY PALEONTOLOGY: ANALYSIS OF THE FAUNMAP DATABASE

Rickard S. Toomey, III, *Illinois State Museum-RCC, 1011 East Ash St., Springfield, IL 62703, toomey@museum.state.il.us*

Paleontologists studying Quaternary taxa and paleoenvironments have long viewed caves as an important source of data. Analysis of the FAUNMAP database of North American Quaternary mammal occurrences confirms their importance. This analysis also elucidates some of the characteristics of faunas derived from cave localities. The FAUNMAP research database contains faunal lists for and information on over 2600 Quaternary mammal sites in the conterminous U.S. Sites identified as caves comprise approximately 11% of these sites. However, these cave sites represent 14% of all analysis units and over 20% of all individual mammal taxon occurrences. Cave sites average approximately 12 taxa per site compared to only seven taxa per site for other types of sites. The importance of caves for paleoenvironmental interpretation using mammalian fossils is even more pronounced. Twenty-six percent of the occurrences of environmentally

sensitive small mammals (Rodentia, Insectivora, Chiroptera, and Lagomorpha) in the research database are from cave sites. Perhaps more importantly, 74% of the mammalian occurrences from caves are from these taxa as compared to 53% of the occurrences from sites other than caves. The FAUNMAP database is an important tool for understanding the characteristics and importance of various kinds of fossil deposits.

RESCUE SESSION

BLACK CAVE, GILA CO., ARIZONA BODY RECOVERY
Raymond C. Keeler, 22354 N. 68th Drive, Glendale, AZ 85310

Three cavers visited Black Cave on Saturday, December 14, 1996. The party included Bill Graff, Cochise County Cavers (CCC) and Southern Arizona Rescue Assn. (SARA) member, Dale Green (CCC), and Elizabeth Robb (CCC and Cochise County search team). The cave is horizontal, mazy and tight in many places with several passages not visited for long periods of time. They found a body a short distance down an extremely tight, down sloping side passage about 50 minutes from the entrance. Traverse distance is less than 120 m, 26 m below the surface. They extracted the keys for identification, left the other evidence in place and reported the situation to the Gila County Sheriff Office. Over the next three weeks, four attempts were made to extricate the body. The last attempt was successful, with the help of 18 cavers underground, electricity, and heavy drilling equipment on a nine hour effort. The long term impact to the cave will probably prove devastating.

SURVEY AND CARTOGRAPHY SESSION

FIBER OPTIC AND LED ILLUMINATORS FOR THE SUUNTO COMPASS
Roger V. Bartholomew, 910 Laurel Street, Rome, NY 13440

An illuminator for the Suunto compass dial has been developed from a fiber optic cable, a specially designed aluminum block to position the fiber optic cable output tip, two AA cells, a common flash light lamp, a toggle switch, a wood block and some electrical tape. The fiber optic cable is long enough to prevent magnetic deviation of the compass needle by the electrical components. The aluminum block requires one 6-32 threaded hole in the Suunto body and is designed not to block the centerline of the Suunto case so that the one-eyed sighting method can be used normally. The compass with the aluminum block will fit in the Suunto case. A self-contained illuminator for the Suunto clinometer has been developed from a green light emitting diode (LED), a plastic right angle bracket, a 3 volt lithium button cell, a micro switch and some 5 minute epoxy. The micro switch is oriented downward so that the thumb holding the bottom of the clinometer in the usual manner can operate it. The unit can be taped or glued onto the clinometer case and it does not block the centerline of the case. The compass with both the LED illuminator and aluminum block described above for a backup will fit in the Suunto case.

U. S. EXPLORATION

RECENT EXPLORATION OF LAVA TUBE SYSTEMS IN KONA AND ON MAUNA LOA, HAWAII
Douglas M. Medville & Hazel E. Medville, Hawaii Speleological Survey

The island of Hawaii contains over 1,000 recorded lava tubes, including the world's longest: Kazumura Cave (surveyed length of 47 km and depth of 888 m) on the east side of the Kilauea shield volcano.

Other extensive systems of lava tubes are found elsewhere on the island of Hawaii: on the western slope of Hualalai, an older shield volcano on the island's west side, and on the north side of the largest volcano on the island: Mauna Loa. In recent years, over 30 km of lava tube has been surveyed in these two areas. The tubes have linear extents of up to 3 km, diameters of up to 15 m, and contain a substantial variety of secondary mineralization including sulfate crusts and soda straws and ribbons up to one meter in length. Some of the tube systems found in historic flows: e.g., the 1801 flow on Hualalai and 1855 flow on Mauna Loa, are compound and consist of several sub-parallel but separately developed tubes that are fairly complex, containing branching and braided passages resulting in passage density comparable to that seen in limestone maze caves. The tubes on Hualalai are near sea level and have a mean temperature of 26°C while those on Mauna Loa are at elevations of up to 3400 m and have mean temperatures as low as 4°C.

THE BLACK HOUSE MOUNTAIN CAVE SYSTEM, FENTRESS COUNTY, TENNESSEE

Todd Rowland and Bryan & Lou Simpson, 750 Avon Fields Lane, Cincinnati, OH 45229

Venturing up Little Jack Creek for the first time, we thought, "Wouldn't it be neat if all the water in Little Jack and its tributaries, Bud and Jim, came out of caves just like what happens up the other branch of Rotten Fork?" Turns out it does. When our motley group of cavers from Ohio, Tennessee, and Kentucky gained access to this unexplored area west of Black House Mountain, we first discovered Red Bud, over 1.6 km, then Temple Falls, with kilometers explored beyond the 460 m Wet Wang entrance crawl, followed by the big overflow tubes of Alastor, and most recently the comfortable mazes of Cornstarch, with three miles mapped. Each of these caves has already been connected to at least one additional entrance. Although Alastor and Cornstarch are on opposite sides of Jim Creek, Cornstarch crosses under the creek, swallowing the river, and connects to an entrance high on the Alastor side. Dye tracing indicates a connection from insurgence entrances high up Bud Creek to Temple Falls and even to Red Bud ~1.5 km away. Down the ridge from the current end of Alastor lie springs and sinkholes for the next mile and a half. With more connections and big discoveries likely in the near future, we hope to integrate the separate caves into a major system.

COLDWATER CAVE—THIRTY YEARS OF EXPLORATION AND DISCOVERY
Mike Lace, 210 E 9th Street #2G, Coralville, IA 52241

On September 17th, 1967, Iowa Grotto cavers Dave Jagnow and Steve Barnett dove into a spring in northern Iowa, finding what would quickly be known as one of the longest and most intensely decorated caves in the upper Midwest. After extensive exploration and mapping trips, the State of Iowa drilled a shaft entrance in 1970 into the mainstream passage to assess the possibility of commercializing the cave. Excessive development costs prompted the State to abandon these plans, and the leased shaft entrance reverted to the private landowners. Since then, cavers from a variety of regional Grottos have assisted the Coldwater Cave project in extending the known limits of this challenging stream cave that was designated a National Natural Landmark in 1987. Distant waterfall climbs, high carbon dioxide levels, impassable dome drains and low airspace traverses in 8.5°C water have required caver stamina and innovative techniques to safely explore the more than 24 km of mapped passageways while preserving Coldwater Cave's fragile beauty. Current efforts including mapping/exploration, water quality studies and the restoration of sensitive areas.

EXPLORATION AND SURVEY OF SPRING CAVE, NORTHERN ARKANSAS
Steve Kaub, PO Box 212, Villa Ridge, MO 63089

This is a physically challenging cave located in a remote area near the Buffalo National River. Prior to 1994, only a small portion of the cave had been explored. The entrance is a small but attractive spring that is known by local cavers but rarely visited. The main obstacle that was preventing the cave from being entered by cavers was water. To enter the cave one must crawl through a water passage to a small entrance room; beyond the entrance room the cave gets difficult. There is another water crawl lined with attractive soda straws, leading back to a sump. Beyond the sump was virgin cave until 1994

when we began our exploration. This area of the cave is full of obstacles. Beyond the second sump, the cave opens up to large stream passage with dry upper passages connecting. By following the stream you reach another near sump, also a third sump which can be bypassed by climbing high through a crack in the ceiling. Beyond the third sump is not completely explored so it is still calling us to return. This is a wetsuit cave that is as tough on your clothing as it is on your body. We have surveyed over 1000 m of passage so far and expect to reach at least 1.6 km of survey before the passage gets too small. But there are still some high leads that could take us to more big cave.

Correction

The wording of William R. Halliday's abstract, "An informative Pigeon River, NC Nitre Department Envelope", that appeared in 59(1): 57 was mistakenly altered in a manner that changed its meaning. The second paragraph should read:

No caves are known near Pigeon River, North Carolina, but roosts of passenger pigeons existed in the area. It seems unlikely that they were mined extensively for saltpetre, if at all. The most likely reason for someone from the Confederate Nitre Department to have visited Pigeon River was to look into its possibilities. If that Department did so at remote Pigeon River, it is logical that it looked at other pigeon roosts. This cover opens a promising new channel for saltpetre research.