

SELECTED ABSTRACTS FROM THE 2007 NATIONAL SPELEOLOGICAL SOCIETY CONVENTION MARENGO, INDIANA

BIOSPELEOLOGY

THE SUBTERRANEAN FAUNA OF INDIANA

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Within Indiana are two distinct cave areas, the south-central karst containing most of the state's 2,000+ caves, and the glaciated southeastern karst. Field work from 1971 to present resulted in sampling over 500 caves for fauna. Approximately 100 species of obligate cavernicoles have been discovered, with over 70 of these occurring in the south-central karst area. Dispersal into the southeastern cave area was limited to the period after the recession of the Illinoian ice sheet, accounting for the paucity of fauna, with only 30 obligate cavernicoles known. The fauna of southeastern Indiana is believed to have dispersed into the area during the Wisconsin glaciation, whereas the south-central karst has been available for colonization over a longer time. Overall the largest numbers of taxa are beetles, including 14 species of *Pseudanophthalmus*, millipeds with 9 species of *Pseudotremia*, and springtails with 7 species of *Arrhopalites*. Several cave systems in the south-central region have faunas commensurate with the status of being global hotspots of subterranean biodiversity, with 20 or more obligate cave species. These sites include Binkleys Cave, Sharpe Creek (Wyandotte) Caves, and the Lost River Cave System. In addition to cavernicoles, an obligate subterranean invertebrate community exists in the epikarst as well as the saturated interstices of soil in the glacial and alluvial plains. Seven species of the copepod *Diacyclops* have been found by sampling cave pools fed by ceiling water migrating downward from the epikarst, hyporheic stream gravel via Bou-Rouche pumpwell, seep springs, wells and drain tile outlets.

THE VJETRENICA CAVE (BOSNIA & HERZEGOVINA): THE WORLD'S HIGHEST BIODIVERSITY CAVE

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Vjetrenica is a complex cave, 6,230 meters long and the biggest in Bosnia and Herzegovina, with numerous water flows and accumulations. The cave is located in the south dinaric karst, between Popovo polje (East Herzegovina) and Dubrovnik (Adriatic Sea, Croatia), as part of the Trebišnjica River system, the longest abyss river in Europe. The region is characterized by strong tectonic and geodynamic activity, high purity of carbonate (99.98%) and 2,000 millimeters of annual rainfall. Since 1950, the cave has been protected as a Geomorphological Nature Monument and in 1964 opened for tourists. Vjetrenica is first mentioned in *Historia naturalis* (77 A.D.) by Pliny the Elder. Hygropetric habitat, water film flow over speleothems, is first described here. Intensive research started in 2000, when the cave was ecologically and topographically surveyed. Permanent monitoring stations established in 2005 measure: air and water temperature, air humidity, air flow direction and speed, and air and water pressure.

In Vjetrenica, 199 taxa have been detected (37 protists and 162 animals) including 91 cave-dwelling taxa (48 troglobitic and 43 stygobitic). Vjetrenica has the world's highest cave biodiversity, including representatives of the following groups: Turbellaria (5), Hydrozoa (1), Gastropoda (12), Bivalvia (1), Nemertina (1), Polychaeta (1), Hirudinea (1),

Palpigradida (1), Araneae (6), Opiliones (2), Pseudoscorpiones (3), Copepoda (5), Ostracoda (2), Decapoda (4), Isopoda (7), Amphipoda (12), Chilopoda (2), Diplopoda (4), Collembola (4), Diplura (1), Thysanura (1), Coleoptera (14), and Vertebrata (1). Vjetrenica is also the type locality for 37 taxa, including 16 endemics and 3 monotypic genera: *Zavalia vjetrenicae* (Gastropoda), *Troglomysis vjetrenicensis* (Crustacea) and *Nauticiella stygiva* (Coleoptera). Some groups have not yet been studied or described (Nematoda, Oligochaeta, Thysanura). Due to changes in hydrology, highway building, intensive agriculture, garbage delay, local quarrying, and lack of state protection mechanisms, Vjetrenica is strongly endangered. Besides continuing research, protection of the whole drainage area, along with sustainable cave management, is necessary.

MARK-RECAPTURE POPULATION SIZE ESTIMATES OF THE MADISON CAVE ISOPOD, *ANTROLANA LIRA*

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I conducted a series of single mark, single recapture estimates of population size (N) of *Antrolana lira* at Madison Saltpetre Cave and nearby Stegers Fissure in Virginia in 1995, 1997, 2004, and 2006. Initial estimates in 1995 and 1997 based on a 24-hour sampling interval between mark and recapture obtained low recapture rates (2.1% – 5.2%), and yielded unreliably high N values of 103 and 104 with large SEs and thus wide 95% CIs. Subsequent estimates based on a two week sampling interval obtained high recapture rates (6.5% – 29.4%) and yielded consistent N values with small SEs and 95% CIs. N values in Madison Cave ranged from 0.36 to 1.02×10^3 , while N values in Stegers Fissure were consistently higher, and ranged from 2.24 to 3.42×10^3 . Estimates from both locations showed little fluctuation from 1997 to 2006. Among a combined total of 2,250 individuals marked and 2,390 individuals recaptured, only two individuals marked in Stegers Fissure were recaptured in Madison Cave and no movement of marked individuals in the opposite direction was detected. The *A. lira* populations at the two locations thus exhibit a classic source-sink relationship. Stegers Fissure serves as the source because it is open to direct input of organic matter and thus can sustain a larger population size than can Madison Cave with no direct access to organic matter input. The situation at Stegers Fissure is likely unique among all known locations where *A. lira* is found.

INVERTEBRATE COLONIZATION AND DEPOSITION RATES OF GUANO IN A MAN-MADE BAT CAVE, THE CHIROPTORIUM, TEXAS

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A man-made bat cave was built in Texas on the Bamberger Ranch Preserve near Johnson City, Texas, by Margaret and J. David Bamberger. The Chiroptorium was built in 1998 on the principle of "if we build it, they will come." It took a few years, but the Chiroptorium was colonized by *Tadarida brasiliensis* bats in summer 2003 and 2004. We began monitoring the bat guano to see when the full community of guano invertebrates would develop in what amounts to a primary succession in a virgin environment. In the winter of 2004–05, average guano depths in both domes were about 5.5 centimeters, and the invertebrates very limited in

number and diversity, with none of the characteristic beetles. A pseudoscorpion, probably *Hesperocheernes mirabilis*, was common in the guano and on walls from the beginning. Spiders *Spermophora senoculata* Duges and *Tidarren sisypoides* Walckenaer, some with egg cases, were found on the walls. By the winter of 2005–06, guano depth had roughly doubled to about 10.5 centimeters, and a diverse community of invertebrates was described, including the beetles *Metoponium* sp. and *Dermestes* sp. In the third winter (2006–07), all structure of the guano deposits had been reduced to dust, probably by the action of a large population of beetles and aided by cattle. Several spiders, *Oecobius annulipes* Lucas, were found on the walls. The Bambergers built it, and the bats and the invertebrates did come, and very quickly.

GENETIC DIVERGENCE AMONG POPULATIONS OF THE MADISON CAVE ISOPOD, *ANTROLANA LIRA*

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The Madison Cave Isopod, *Antrolana lira*, is a federally threatened isopod that inhabits phreatic aquifers in the Shenandoah Valley of Virginia and West Virginia. In this study, I analyze a 658 bp region of mtDNA corresponding to the cytochrome oxidase *c* subunit I gene obtained for 70 individuals from 9 locations. Analysis revealed three highly divergent haplogroups, which are found in separate geographic areas. Within these haplogroups genetic divergence is low, suggesting gene flow between sites. Over 99% of the genetic variation of the species corresponds to among group variation. Haplogroups became isolated between 3 and 21 mya.

The synclinal nature of the Shenandoah Valley and the presence of non-soluble rock likely contribute to genetic isolation. Invasion of the Shenandoah Valley probably occurred during the early Miocene. This may have occurred in the north followed by dispersal. Conversely, haplogroups may represent three independent invasions.

MICROBIALY-DERIVED CARBON IN KARST WATERS

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Cave and karst ecosystems can be severely impacted by the scarcity of a continuous nutrient supply. However, some subsurface, and specifically cave, ecosystems do not rely exclusively on surface-derived (allochthonous), photosynthetically-produced organic matter. Although microbes in general are largely responsible for the availability and fate of dissolved organic matter (DOM), the role of microbes in the autochthonous production and overall processing of DOM in karst is poorly understood. We used fluorescence spectroscopy to characterize DOM from sulfidic caves and springs where microbial communities have been previously described. Because few studies have been conducted on systems with significant microbial contributions to DOM in the absence of allochthonous influences, our results uniquely provide an array of signatures constrained by microbial influences. We applied these signatures to understand DOM types from the saline-waters of the Edwards Aquifer, Central Texas. Cave and aquifer DOM had very different spectral features and was significantly less fluorescent than allochthonous DOM from surface and sediment pore waters. In contrast to most surface samples with quinone-like fluorophores, a significant shift in emission maxima over the range of excitation wavelengths for the cave and aquifer waters indicated a more heterogeneous collection of fluorophores and higher relative amounts of protein-like and microbial DOM. The cave, spring, and aquifer waters also lacked any significant contribution from humified DOM. These results, indicating a microbial source for DOM in the saline-waters, have important implications for carbon sources and cycling in the Edwards Aquifer ecosystem.

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IDENTIFICATION OF THE MICROBIAL COMMUNITIES ASSOCIATED WITH ROOTS IN NEW MEXICO LAVA TUBES

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Although roots have been found to be an essential energy source in lava tubes around the world, the role of roots in New Mexico lava tube ecosystems and their microbial communities is unknown. We investigated root and associated fungal and bacterial communities from two lava tubes in the El Malpais National Monument using culture-dependent and culture-independent methods. Samples of these communities were taken aseptically. R2A culture medium was inoculated and incubated on site with small samples of root material or sterile swabs of the wall or root microbial mats. Root and fungal samples were studied using scanning electron microscopy (SEM) to detect microbial interactions with the roots. DNA was extracted and purified using the MoBio Power Soil DNA Extraction Kit, amplified using polymerase chain reaction (PCR), cloned using TopoTA Cloning and sequenced using Big Dye Terminator v1.1 sequencing to identify closest relatives of genetic sequences from the cave materials. Alignment was done using ClustalW and a neighbor joining phylogenetic tree with 100 bootstrap replicates was constructed using Paup version 4.0b10. Preliminary results show that microorganisms cultured from the roots are grouping with known root-associated bacteria. Fungal DNA sequences also were detected associated with the roots. This study suggests that the roots support a diverse microbial community in the lava tubes and is one of the first projects to look at root associated microorganisms in cave environments.

THE COMPARATIVE ROLE OF MICROBIAL METABOLIC ACTIVITY VERSUS INORGANIC PROCESSES IN THE PRECIPITATION OF CALCITE

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In order to investigate whether active metabolic microbial process dominates over passive geochemistry in the formation of calcite polymorphs, we are examining calcium carbonate (CaCO₃) precipitation and dissolution by bacterial species from hypogean cave environments. Microbial species were isolated from CaCO₃ “popcorn” deposits within Grayson-Gunnar Cave, Kentucky, based on their ability to deposit CaCO₃ crystals on Boquet B4 media or to dissolve calcite in a CaCO₃ enriched “top” agar. Current research is aimed at determining if an organic calcium salt is a possible energy source that drives such phenomenon and to identify the gene(s) responsible for this cellular function. Examination of the crystal structure produced by precipitating species using scanning electron microscopy demonstrates bacterial-like footprints in, and on, the surface of these crystals. These data have shown the same species can precipitate various mineral forms of CaCO₃, including calcite, vaterite, and aragonite. By correlating the structure of the CaCO₃ crystals with environmental growth conditions of individual species using powder x-ray diffraction (XRD), we hope to correlate microbial metabolic activities with CaCO₃ precipitation. By studying the conditions that similarly allow dissolution of CaCO₃, we hope to better understand the role that CaCO₃ plays on microbial growth, Ca₂₊ detoxification and metabolic adaptation to CaCO₃ rich environments.

ENHANCING COMMUNICATION AND KNOWLEDGE DISCOVERY AMONG KARST BIOSPELEOLOGISTS: THE ROLE OF THE KARST INFORMATION PORTAL (KIP)

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Speleology is an intrinsically multidisciplinary field of study that draws upon a substantial grey literature (for example, agency research reports) that is poorly indexed, difficult to access, and generated in many different languages. The creation and implementation of the Karst Information Portal (KIP) beginning in 2005 addresses these and other information access and management problems by focusing on providing a global portal that will provide a gateway to the Web for karst information and services. Digital versions of many karst resources will be available through KIP. Databases, datasets, bibliographies, images, grey literature, and the like that have been created by karst scientists worldwide will be accessible through KIP federated searching (simultaneous search of multiple data sources) of identified karst sites on the Internet. The core idea is not to recreate databases that have been developed by others, but to make those that exist (or are being developed now and in the future) more universally available and provide advanced tools for using them. In June 2007, an enhanced KIP was launched that includes *The Guide to Speleological Literature* database, a scanning electron micrograph repository, and links to key electronic karst resources. Knowledge discovery, commenting by users, and collaborative workspaces are being tested through the SEM (scanning electron microscopy) database in a joint project with Los Alamos National Laboratory. Biospeleology partners are needed to create and maintain databases of information and resources pertaining to biospeleology that can be linked to KIP.

A MULTIDISCIPLINARY, COLLABORATIVE APPROACH TO CAVE SCIENCE EDUCATION AT BELEN MIDDLE SCHOOL

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Nationwide, K-12 teachers are facing many challenges in teaching science, including inadequate funds to purchase supplies, inability to allow students to participate in labs because of the disciplinary issues, and an overall decrease in general science understanding among students. Here, we illustrate how caves can be used to effectively teach ecology and geology to 7th and 8th grade science students. As part of the NSF-funded GK-12 program, we combined a biologist, a geologist, and a teacher to develop and teach science in an interdisciplinary, inquiry-based and research-based lesson for a full inclusion Title I public school classroom. Cave-based lessons were developed to cover New Mexico state science standards for 7th and 8th grade. Students investigated adaptation in troglobites in a lab where students pretended to be blind cave fauna. Students graphed their results and further discussed how troglobites adapt to constant darkness, as well as levels of cave adaptation. On day two, students drew their favorite animal as if it was a troglobite. Students then learned about basic speleogenesis, observed dissolution of limestone compared to other rock types, and virtually toured a cave using the 360° Lechuguilla Cave Virtual Tour. Finally, students watched a cave science video and had an open discussion with cave scientists about cave research and exploration. Overall, students were very interested in caves and cave science, and all three labs in our lesson could be used to teach science in a public school classroom.

CAVE CONSERVATION AND MANAGEMENT

HUMAN DIMENSIONS RESEARCH AND THE KARST INFORMATION PORTAL Patricia E. Seiser¹ and Todd A. Chavez²

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In the natural resources disciplines, human dimensions research aims to understand the role of human interactions in the various biological, physical, and social components of ecosystems. Successfully applying this knowledge to decisions affecting environmental processes and their societal outcomes depends on collaborations among interrelated disciplines in the social and behavioral sciences, humanities, communication sciences, and related interdisciplinary studies. Success is also based on access to reliable sources of scientific and technical information. Some of the difficulties in stewardship of karst and cave ecosystems arise from the limited availability of information concerning human-karst relationships.

The Karst Information Portal (KIP) is an evolving international community of scientists, information specialists, and other researchers seeking to promote information sharing and access to published and unpublished research in order to advance karst, cave, and aquifer research and stewardship via the Internet and information-related technologies.

Researchers at University of South Florida conducted a study to map the domain of karst literature. The data has been used to design strategies to aggregate and evaluate the representation of information within KIP. One finding was that a large amount of cave and karst scientific and technical information resides in gray literature, much of which is currently not readily available to researchers, decision makers, and the public.

KIP has the potential to facilitate communication of scientific and technical research and findings between cave and karst land stewards, policy makers, community planners, social scientists, and funding agencies. The resulting collaborations have the potential for generating innovative solutions to the critical challenges of karst and cave ecosystem stewardship.

CAVE AND KARST PROTECTION INITIATIVES FOR MODERATE AND LOW INCOME LANDOWNERS

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Numerous private, state, and federal programs can assist landowners to protect karst features and caves. Programs such as EQIP, CREP, and Agricultural Best Management Practices help fund projects on a cost-share basis. Sinkhole cleanouts, livestock exclusion, and establishing vegetative buffers around karst features are eligible projects. These programs require some level of financial commitment by the landowner. Landowners typically bear the initial cost of constructing conservation practices; government programs reimburse a portion, usually 50% to 75% upon installation. The Virginia Department of Conservation and Recreation Karst Program has negotiated with Division of Soil and Water Conservation staff to count donated volunteer labor value toward landowner share of project cost. The Karst Program is working with nonprofit land trusts and cave conservancies to establish a revolving loan fund to defer upfront landowner expenses. Many otherwise enthusiastic owners forego government sponsored conservation programs due to a lack of personal financial resources.

Private and government grants occasionally fund cave gating projects and cave management initiatives on private lands at little or no cost to the landowner. Landowners in Virginia may elect to protect biologically significant cave and karst resources through voluntary Natural Area Dedication, Natural Area Management Agreements, or Natural Area Registration through the Department of Conservation and Recreation Natural Heritage Program.

Landowner donations of conservation easements can serve to protect cave and karst resources. Conservation easement donations may generate significant federal tax deductions. In Virginia, conservation easement donors may realize substantial cash income through the sale of the resulting Virginia State Income Tax Credit.

CAVE RESTORATION FORUM

THE RICHARD BLENZ NATURE CONSERVANCY'S BUCKNER CAVE GRAFFITI REMOVAL PROJECT

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Buckner Cave is located a few miles southwest of Bloomington, Indiana, in the south central part of the state, in an area referred to by cavers as the Garrison Chapel Valley. The area contains many caves, several of which are more than one kilometer in length, including Buckner at ~4.5 kilometers surveyed length.

Historically, the cave and property unfortunately received heavy abuse and vandalism. However, a major turnaround began to take place in the early part of the 21st Century due to the presence of a property caretaker. Improved stewardship led to the formation and incorporation of the Richard Blenz Nature Conservancy in 2005, which took over management of the property and cave. One of the restoration efforts has been The Buckner Cave Graffiti Removal Project, coordinated by Dave Everton. We used the Peppersauce Cave Conservation Project's sand-blasting equipment and process, which was specifically developed for removing graffiti inside caves. The project included documentation of historic signatures, assessment of impact to the cave environment, removal of contemporary graffiti, and restoration of the cave environment to a pre-mitigation level. Photographs illustrate the project methods, and show before and after conditions.

RESTORATION IN ECHO RIVER AND RIVER STYX IN MAMMOTH CAVE PERFORMED BY NATIONAL SPELEOLOGICAL SOCIETY VOLUNTEERS

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Beginning in 1989, NSS volunteers began doing cave conservation projects in Mammoth Cave National Park. Over the past 18 years, a tremendous amount of work has been donated during roughly 80 restoration weekends and week long camps. The person-hours volunteered come to over 59,000, and if valued at the modest rate of \$15 per hour, then the monetary value of the contribution comes to \$888,000.00. This partnership has obviously been and continues to be a great benefit to Mammoth Cave National Park.

Among the most significant projects taken on by the NSS was the removal of an 1,100-foot-long elevated boardwalk in Echo River and River Styx plus removal of lighting infrastructure for this section of the cave. Over a nine-year period, the boardwalk was dismantled with pry bars and sledgehammers—volunteers often worked in deep water wearing wetsuits. A group of deaf cavers distinguished themselves in this work, especially through the invention of a piling puller by John Vargo. Dismantled pieces were carried to “chop shops,” reduced to manageable size, and bagged. As many as 900 bags in a day were carried to Mammoth Dome, passed up the tower and out the Historic Entrance, loaded into a truck, hauled, and tossed into a dumpster. Removal of this rotting, creosote-treated wood has greatly benefited habitat for cave life including the endangered Kentucky cave shrimp.

RESTORATION AT PARKS RANCH CAVE—A YOUTH-INITIATED CAVE PROJECT

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Parks Ranch Cave is a gypsum cave near Carlsbad, New Mexico, located on Bureau of Land Management land. On January 1, 2006, it was discovered that Parks Ranch Cave had been vandalized with spray paint and permanent markers. Lucas Middleton, a caver from the local Speleo Venture Crew, chose to make the restoration of Parks Ranch Cave his Boy Scout Eagle Project. Three trips were made to clean up Parks Ranch Cave. Help was received from Boy Scout Troop 86, Speleo Venture Crew, Pecos Valley Grotto, and other concerned cavers. The cave was restored as close as possible to pre-vandalism conditions using nylon-, brass-, and steel-bristled grout brushes along with rotary drills. For this restoration project the hope is that noncavers and perhaps many experienced cavers would not be aware of the vandalism and subsequent restoration that has occurred. It took a total of 115 caver-hours to restore the cave. A follow-up assessment trip indicated that another restoration trip will be planned in the future after the cave has had time to heal itself.

CAVE CONSERVATION AND RESTORATION: NEW NSS BOOK IS CATALYST FOR NETWORKING STATE-OF-THE-ART INFORMATION

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Recently published by the National Speleological Society, the new book titled *Cave Conservation and Restoration* (Hildreth-Werker and Werker, 2006 edition, ISBN 1879961-15-6), is receiving attention from cave conservationists around the globe. The 600-page volume contains a wealth of detail from 46 contributors describing state-of-the-art tools and methods for cave conservation, restoration, speleothem repair, and minimum-impact caving ethics. There are more than 400 photos and illustrations with a 16-page color insert. This new publication includes philosophy and practical suggestions for making sound conservation decisions based on assessing interdisciplinary up-to-date information. The tome advocates that the foremost concern in every decision related to a cave should be the perpetuation of speleological processes, values, and resources. The new text is proving to be a catalyst for conservation-centered discussion, international information networking, quantitative conservation research, and interactive collaborations working to improve methods.

PUBLIC EDUCATION EQUALS PUBLIC SUPPORT

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In October of 1994, cavers gathered in New Braunfels, Texas, and established the Texas Cave Conservancy (TCC). We developed a new approach to urban cave management. “The Texas System” involves obtaining cave-related land management contracts and grants, building cave parks within urban areas, and conducting public education activities.

Through high-profile initiatives and public education efforts, the TCC has obtained grants. Cavers are “the cave experts” and there is money available to assist in the acquisition and protection of caves.

Highlights from TCC's history include:

- 1986 The City of Austin, Texas, passed the Comprehensive Watershed Ordinance requiring caves and sinkholes to be preserved.
- 1990 Seven species of cave invertebrates in the Austin, Texas, area were listed under the Endangered Species Act.
- 1994 The TCC was formed to conduct land management, cave preservation activities, and public education on tracts of open land containing caves.
- 1995 We built trails and picnic areas and placed signs at the cave preserves. Urban cave preserves create long-term cave protection opportunities.
- 2003 We celebrated moving into our new headquarters in Cedar Park, Texas. The house, along with three small caves and 4.25 acres, facilitates our fund-raising efforts.

- 2004 We hosted our first public education event, Cave Day, in Cedar Park, Texas. Two times a year, in April and in September, 300–500 visitors join us to learn about caves and cave life. The Texas Hotel Association donated \$5,000 to develop educational material for Cave Day. Later they donated \$6,500 to develop and place 40 cave signs at the Westside Preserve to create a new ecotourist attraction.
- 2005 The TCC assisted in the transfer of the \$10,000,000 Discovery Well Cave property to the City of Cedar Park. This park will be the future Cave Day site.
- 2006 A \$13,000 grant was obtained from the U.S. Fish & Wildlife Service to develop Avery Ranch Cave and Dies Ranch Cave for public education visitation. Upon obtaining a corporate sponsor, Avery Ranch Cave will be used an educational show cave.

The goal of the Texas Cave Conservancy is to create the same level of Texas support for cave protection that Bat Conservation International has created to protect bats.

URBAN CAVE MANAGEMENT—THE TEXAS SYSTEM

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More than 1,000 Texas caves in urban areas are threatened by rapid development. Many are set aside for water protection or for cave-related endangered species. This creates an opportunity for cave conservancies or grottos. The Texas Cave Conservancy builds parks and trails, develops educational materials, conducts fire ant control, and monitors the caves as part of our long-term cave protection efforts. How can a cave-related land management operation be started?

- Check the language in your Articles of Incorporation—can your conservancy or grotto act as a cave management business?
- Do you have General Commercial Liability and Volunteers Insurance?
- Do you have support from individuals with expertise in sales, geology, biology, accounting, public education, drafting, construction, cave laws, and the like?
- Some tasks such as monthly inspections do not work well through volunteers—are you open to hiring cavers as “independent contractors”?
- How can we work with developers to obtain contracts in such areas as site evaluation, cave gating, park building, development of educational material, and cave management? When they need surveyors or carpenters, they hire them. When they have caves, cavers have the ability to solve their “problems.”
- Can you invest \$10,000—\$15,000 to obtain the donation of a significant cave and land from a developer? Can you build high-quality cave gates, lay out and build wood mulch trails, develop and place signs and picnic tables, and so on?
- Are you prepared to invest time and money into this exciting fundraising, karst-protecting opportunity?

With urban caves in the hands of developers, you have at least two ways to negotiate. To obtain ownership of a good cave, offer to pay all costs: legal, gating, park building. If the caves are not ones that you want to own, offer to build a park for the developer for a reasonable price (\$5,000–\$10,000) and have them pay you a monthly fee (\$100–500) to manage them. Either way, the “cave problem” is solved for the developer.

CAVES OF OUR NATIONAL PARKS AND PUBLIC LANDS

MANAGING CAVES IN OZARK NATIONAL SCENIC RIVERWAYS: A PUBLIC-AND-PRIVATE PARTNERSHIP

R. Scott House

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The Ozark National Scenic Riverways, a unit of the National Park Service, contains more than 340 caves. Managing these resources is difficult given the limitations of budgets and personnel. Through a series of agreements with Cave Research Foundation (CRF) and the efforts of caver volunteers, cave management at the Ozark Riverways is accomplished for relatively minimal funding. CRF works through the Resource Management office to coordinate the work of paid and unpaid help in performing a wide range of management activities on lands within the park. Special emphasis will be given to the mechanisms and personnel management through which this is accomplished.

THE HOOSIER NATIONAL FOREST: A HOME FOR RARE AND DIVERSE CAVE SPECIES, AND A CASE IN POINT FOR KARST EDUCATION AND PRESERVATION

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Located in southern Indiana, the Hoosier National Forest comprises approximately 25 percent of the public land in the state. Home to over 160 caves, the Hoosier has a vital role in cave conservation. Within the last few years, the Hoosier has completed an extensive amount of work to inventory cave fauna. The baseline inventory has described several species new to science and documented new distributions of previously described species. Due to the extreme isolation and harsh conditions of the cave environment, many of these species, especially cave obligates, are rarely found. A three year study of cave fauna on the Hoosier included the discovery of 53 troglobitic species, over 30 species new to science, and 75 species of significant global rarity. The high number of cave-associated species with global and state viability concerns underscores the importance of karst habitat on the Hoosier. Educating and engaging the public about the singular life forms that exist in the remarkable karst topography that stretches across the United States is an important component of cave management on the Hoosier. The film, *Caves: Life Beneath the Forest* was created to build support for cave conservation by giving the general public a chance to see creatures that they will likely never encounter on their own. By engaging the public, the Hoosier hopes to instill in them an appreciation for caves and cave species and to develop life-long stewards of this fragile resource.

THE DRAFT CAVE, KARST, AND MINE MANAGEMENT PLAN, AND THE RAPID CAVE ASSESSMENT AND CLASSIFICATION SYSTEM, GRAND CANYON NATIONAL PARK

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Grand Canyon National Park's[®] (GCNP) vast cave and karst resources are poorly understood. Concomitantly, these resources are experiencing increasing pressure from visitors. The National Park Service is mandated to proactively manage and protect these resources. GCNP has developed a draft Cave, Karst, and Mine Management Plan that provides guidelines for the protection and management of cave and karst resources. The plan contains specific rules, regulations, and protocols designed to protect resources while safeguarding visitor enjoyment. The plan outlines procedures for systematic inventory, mapping, classification, and assessment of cave resources and for permit issuance. This plan recognizes visitor use demands and addresses recreational use, resource protection, research, education, and public safety. This plan will enable managers to make decisions on each cave use by:

- identifying resources at risk
- setting appropriate recreational use levels and/or restrictions and
- identifying monitoring, research and restoration needs.

A Rapid Cave Assessment protocol was developed to provide consistent, detailed information needed to begin the classification process, make determinations, and build a database. Cavers are asked to provide general information on the cave and information specific to biologic,

physical, paleontological, cultural resources, and human impact. The Park requests that cavers rank caves according to specific values and provide management recommendations. This information provides the basis for cave classification and helps define its management. Effective implementation of the plan is largely dependent on establishing strong partnerships with stakeholders and the general public. Volunteer recruitment will greatly accelerate this process and help in solidifying partnerships and support.

MULTIDISCIPLINARY MANAGEMENT AT MAMMOTH CAVE NATIONAL PARK

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In 2006, Mammoth Cave National Park received 740,500+ visitors, with over 358,000 of those visiting the cave. Recent infrastructure projects include:

- A new water system that connects the Park to a regional system, eliminating 30-year-old leaking water lines.
- A new cave electric-lighting system that will be energy efficient and protect the resource by reducing algae growth

The Park has no authority on lands outside the administrative boundaries, but the land, water, and air quality outside the park affect the park. Partnerships with local groups to protect resources are vital to Park health.

The Park provides support and space to the Director of Central Kentucky Personal Responsibility in a Desirable Environment, which coordinates community sinkhole cleanups. The park supports the Green River Conservation Reserve Enhancement Program to create riparian buffers between agricultural discharge and pollutants and the water flow. The Friends of Mammoth Cave National Park will help individuals and groups to support the park financially and through in-kind contributions.

Park volunteers perform sinkhole clean-ups, cave mapping, research projects, and visitor contacts. In August 2005, volunteers from the National Speleological Society finished an eight-year project, removing 150 tons of creosote-soaked timbers from Mammoth Cave. Since 1989, the NSS has contributed more than 54,000 hours of work.

Research and teaching partnerships include the Mammoth Cave International Center for Science and Learning, the Cave and Karst Center at Western Kentucky University, and over 50 individual science research partnerships. Multiple tourism partnerships play an important role in planning, marketing, and decision making.

MAMMOTH CAVE INTERNATIONAL CENTER FOR SCIENCE AND LEARNING

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The Mammoth Cave International Center for Science and Learning (MCICSL) is part of the national network of 17 research learning centers located within the National Park System. MCICSL was created in 2004 as a partnership between Mammoth Cave National Park and Western Kentucky University. Funding, logistical support, and governance of MCICSL are shared equally by the two entities. The overall goal of the national research learning center network and the MCICSL is to increase the amount and effectiveness of research and to improve science communications by:

- Facilitating park use for scientific inquiry
- Supporting science-informed decision making
- Communicating the relevance of research and providing access to research knowledge
- Promoting resource stewardship through partnerships

MCICSL has been active for only a short time. The director has only been in place for two years, and the education specialist for about six months. In spite of its youth, MCICSL has positively impacted resource

management and educational outreach at Mammoth Cave. The center hosted an NEH-funded workshop for community college professors on place-based history and humanities education. It developed a multi-park, multi-region, NPS-funded project to study controlling algal growth through optimal cave lighting. MCICSL hosts international researchers and cave managers during park visits, provides technical assistance for Mammoth Cave staff, helps coordinate park research, and works with environmental education staff in programming for students and adult learners. Recently the center began managing the park research permitting system and providing summaries of recent research to the interpretive staff at the park.

CAMP BULLIS MILITARY TRAINING RESERVATION: A CENTER OF MULTIDISCIPLINARY KARST RESEARCH

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Federal support and funding of karst research at the Camp Bullis Military Training Site, Texas, has proved a role-model for karst investigations and been key to the discovery of hydrogeological and biological relationships for improved management of karst resources in the central Texas region. Nearly 100 caves and 1,300 karst features have been located to date on the 113.3-square-kilometer reservation. Their study has redefined concepts of groundwater movement in the area by demonstrating groundwater flow between formations previously believed hydrologically separate, identifying modes of cave development distinctive to particular lithologies, delineating flowpaths in units once thought impermeable, and using the information to identify zones of contaminant movement, and endangered and rare species distribution. Specific examples follow. The upper 39 meters of the Glen Rose Formation, regionally the lower confining unit for the Edwards Aquifer, are highly permeable and hydrologically continuous with the Edwards, traced at velocities as great as nearly 4 kilometers per day. Detailed surveys, exceeding state standards, have found one to two orders of magnitude more caves and karst features than in geologically identical neighboring properties, prompting review of existing survey requirements. The Dolomitic Member of the Kainer Formation in particular forms topographically subdued features that often appear insignificant, but if excavated, prove to host hydrologically and biologically important caves. Federally listed endangered karst invertebrates have been found in 23 caves, and their distribution is defined by continuity of lithologic units. Fourteen endangered species caves in the Dolomitic were discovered or their known extents substantially expanded by excavation.

COMPROMISE: THE IMPACT OF CAVE SURVEY IN GAP CAVE, CUMBERLAND GAP NATIONAL HISTORICAL PARK, MIDDLESBORO, KENTUCKY

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The Cave Research Foundation has been surveying Gap Cave since 2003. Cavers had logged over 10,000 hours creating more than 2,600 stations in 12.53 miles (20.165 kilometers) through March 2007. The means, methods, and materials of the survey are under scrutiny. Cave survey is seen as a means of defining the resource that is the cave and a tool for preservation of a fragile environment. Does the way cavers prepare for a survey trip and conduct themselves underground make a difference in the level of impact? Are some tools, supplies, and materials better for a low impact survey? A brief look at these issues raises questions about what is normally permitted or prohibited. More permit restrictions may be justified, but regulators need to provide reasonable solutions so the survey of caves on public lands can continue.

UPDATE ON THE SYSTEMATIC INVENTORY AND SURVEY OF THE CAVES IN GRAND CANYON – PARASHANT NATIONAL MONUMENT, ARIZONA

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Cave resources of Grand Canyon – Parashant National Monument are virtually unknown. During summer 2005 and early-spring 2006, we surveyed all 26 known caves on the Monument. Systematic procedures for mapping and inventorying geological, hydrological, paleontological, archeological, and biological resources were developed and refined. Our study was the first regional systematic survey of caves in Arizona. Geologically, caves were found within Permian Kaibab Limestone, Mississippian Redwall Limestone, sandstone and basalt. We also documented airflow in 10 caves. Several caves may offer great opportunities for paleoenvironmental reconstruction. Two potentially significant archaeological sites were identified, and most caves were used during prehistoric and historic times. Several of the caves act as swallets and may be significant aquifer recharge points. We also inventoried vertebrates and invertebrates. Data collected during this study should be considered baseline data, which will be useful in identifying additional research needs on the monument. These data will also be used in developing cave resource management plans for these caves. The protocols developed have proven themselves in the field and are currently being used throughout the state.

In the last year we have incorporated the use of volunteers and have discovered over 20 new caves and numerous new species of invertebrates.

GEOLOGY AND GEOGRAPHY

MONITORING SYSTEMS IN HYPERTHERMIC AND HYPERCARBIC CAVES

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Unlike industrial exposures to hypercarbia (dangerously elevated CO₂), spelean hypercarbia has two radically different scenarios: (1) replacement of oxygen by CO₂ (as occurs in confined spaces in the industrial setting) and (2) simple addition of CO₂ to the atmosphere from volcanic or other sources. Further, quasi-political factors essential to promulgation of industrial standards are irrelevant in quantifying standards for investigations in caves. A refereed field study by Howarth and Stone has shown that investigations are feasible in normothermic caves containing 6% CO₂ (60,000 ppm) and 15% oxygen. In hyperthermic caves in Kilauea Caldera, HI studies have been performed in temperatures up to 68 degrees Celsius (140 degrees F); theoretically they should be possible in such caves up to about 24% CO₂ (240,000 ppm) and 15% oxygen. Field trials and web search demonstrate that current American CO₂ monitors are designed for industrial environments, not cave environments. In cave environments, hypoxia (dangerously decreased oxygen) actually is the acute killer, not hypercarbia and use of exercise oximeters supplemented by clinical observation may be a desirable alternative to CO₂ monitors. Resolution of the issue is hampered by limited documentation of field observations, variations in composition and velocity of cave air, instrumental artifacts, limited access to recent aerospace data, and administrative incompetence. It is proposed that the 2009 International Congress of Speleology schedule a special session on this topic.

UNDERAPPRECIATED CAVES OF THE SOUTHWEST: SPELEOGENESIS IN THE CASTILE FORMATION, EDDY COUNTY, NEW MEXICO AND CULBERSON COUNTY, TEXAS

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The Castile Formation crops out over ~1,800 square kilometers in Eddy County, New Mexico, and Culberson County, Texas. Evaporite diagenesis has resulted in significant alteration of sulfate rocks, producing variable lithologic fabrics, including laminated, massive, nodular, and tabular (selenite) gypsum, gypsite, and calcitized evaporite. In addition to fabric alteration, speleogenetic processes abound within the outcrop region as evidenced by abundant sinkholes and caves. Over 500 individual features (caves and sinkholes) have been physically identified in the field; over 3,000 features have been identified from GIS-analyses; and over 9,000 likely exist.

Caves are developed in all lithologic fabrics and range from small, laterally-limited, epigenetic caves to complex, hypogenic forms. Epigenetic caves have simple morphologies, largely controlled by local brittle deformation. They generally exhibit well-developed, arroyo-type sinkhole entrances with rapid decreases in cave aperture away from insurgences. Hypogenic caves tend to occur in dense clusters, and range from simple, steeply dipping features to laterally extensive, maze-like forms. Specific morphological features within caves (that is, risers, cupolas, and half-tubes) provide unequivocal evidence of the free convection component of mixed convection dissolution within a confined speleogenetic system.

The extent, distribution, and geomorphic variability of karst development within the Castile outcrop region suggests that evaporite karst in the southwestern United States deserves greater recognition in North American cave and karst science. Not only do caves exhibit patterns and morphologies indicative of a complex, confined hydrologic system, but diverse secondary mineral deposits indicate that the system continues to evolve through the epigenetic phase.

HYPOGENIC SPELEOGENESIS SOUTH OF THE GUADALUPE MOUNTAINS: CAVES, BRECCIAS, CASTILES, AND MORE

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Hypogenic speleogenesis is common within the Castile Formation of the Western Delaware Basin (southeastern New Mexico and far west Texas), as evidenced by the clustered distribution of karst features within the outcrop region and extensive free-convention features observed in individual caves. Dense clusters of hypogenic caves are commonly associated with calcitized evaporites and selenite masses, suggesting a genetic relationship. Abundant diagenetic patterns within the region indicate extensive, regional, confined speleogenesis that is not limited to cave development.

Brecciation is common throughout the Castile Formation, indicating extensive subsurface dissolution and collapse processes. Breccia pipes, resulting from upward stoping of subsurface voids, suggest confined transverse flow, while blanket breccias and subsidence troughs suggest confined lateral flow component. Calcitized evaporites are extensive throughout the Castile Formation, resulting from bacterial sulfate reduction in the presence of ascending hydrocarbons. Large, economic native sulfur deposits associated with some calcitization indicate limited cross-formational flow of oxic waters contemporaneous with calcitization, while selenite masses associated with other calcitized masses indicate significant intrastratal flow of oxic waters locally.

Hypogenic caves, breccias, calcitization, native sulfur and selenite masses suggest that hypogene processes have dominated sulfate diagenesis within the Delaware Basin. Surface denudation and epigenetic processes significantly overprint hypogene products, resulting in greater complexity in the speleogenetic evolution of the Castile Formation.

INTERPLAY OF HOLOCENE CLIMATE AND GEOMORPHOLOGY IN THE CENTRAL APPALACHIANS AS RECORDED BY CAVE DEPOSITS

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Mid- to late-Holocene climate fluctuations are recorded in a stalagmite (BCC-002) recovered from Buckeye Creek Cave, West Virginia. The mid-Holocene Hypsithermal, a 2000-year-long warm period, is marked by larger values of $\delta^{18}\text{O}$ calcite in BCC-002. Climate was apparently drier during the Hypsithermal; values of $\delta^{13}\text{C}$ calcite are comparatively large during the Hypsithermal. Climate destabilized at the end of the Hypsithermal, which ended abruptly and was closely followed by several short, very cool climate excursions. The late Holocene was substantially moister than the mid-Holocene.

The climate fluctuations are inferred to have translated to changes in the geomorphology of the local master stream—the Greenbrier River. Colonial Acres Cave has received sediments from the river throughout the Holocene, but sedimentary structures and textures vary with time. Bat bones and other evidence of subaerial exposure between floods are found throughout silt-dominated sediments, except during the Hypsithermal, a period characterized by the deposition of clayey silts containing insoluble particles liberated from cave ceilings during sustained backflooding. Three outlets must be blocked to backflow the cave, which would have occurred if the riverbed filled with sediment. Warm, dry periods, such as the Hypsithermal, are known to produce channel infilling. The Greenbrier River may have risen as much as 4 meters. Global warming may return the Earth to Hypsithermal-like conditions and possibly lead to renewed channel infilling. The latter would bring about deeper floodwaters on and more frequent flooding of floodplains, which bodes ill for the many riverside cities in the region.

GEOLOGIC AND HYDROLOGIC INVESTIGATIONS OF EL CAPITAN PEAK ALPINE KARST, PRINCE OF WALES ISLAND, SOUTHEAST ALASKA Melissa Hendrickson¹ and Kevin Casey²

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The Tongass National Forest of southeast Alaska, USA, covers nearly 6.9 million hectares of mountainous offshore archipelago with extensive mature temperate rain forests. Because of the accretionary terrane geologic setting, the geology there is extremely complex and heterogeneous, and includes numerous blocks of limestone that have been intensively karstified. These extensive areas of carbonate bedrock are focused mainly on the northern portion of Prince of Wales Island. El Capitan Peak consists almost entirely of Silurian age Heceta limestone, stretching from sea level to 850 meters. Work during the 2005 and 2006 field seasons focused on two deep pit systems. Geomorphologically, the caves are located on a north facing cliff band which is likely the rim of a glacial cirque. The glacial chronology of this region is poorly understood, which makes it difficult to determine the age of these landscape features. Tracer techniques were used to delineate the flow paths of the two separate systems. While quite close, the two systems have distinctly different hydrology, as the water flows along west-southwest to east-northeast shear zones. These shear zones are conjugate to the major north-south trending strike slip faults which predominate in the region. The major north-south trending strike slip fault, which bisects El Capitan Peak, creates a hydrologic divide as previous traces on the west side of the fault all flowed to the west. This corresponds well with other karst areas on northern Prince of Wales Island where dye tracing has shown groundwater flow favors paths along the shear zones.

THE CAVES AND KARST OF REDMOND CREEK, WAYNE COUNTY, KENTUCKY

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Redmond Creek, the headwaters of Otter Creek in southern Wayne County, Kentucky, flows south through a large sinkhole formed in

Mississippian-age limestones within the Cumberland Plateau. Caves and karst features within the sink are prevalent, and an ongoing project of the Central Ohio Grotto of the National Speleological Society has focused on documenting, exploring, and surveying these features. To date this project has inventoried over 40 caves and initiated surveys in 10, surveying just over 10 miles of passage. Study of the caves within the Redmond Creek sinkhole has revealed several unique characteristics. The lithology within the sink has caused the development of cave “couplets” that transmit water across the Hartselle Formation. Pale conduits were developed along the strike oriented piracy routes through ridges. Present day phreatic and epiphreatic conduits act as shallow phreatic system with bypasses and lift tubes. The phreatic conduits are alluviated, resulting in a stable baseflow, high clarity spring.

SHOW ME THE STRUCTURE: HOW THE NEW DISCOVERIES IN GRAND CAVERNS EXPLAIN CAVE HILL

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Caves have been overlooked by those doing geologic mapping. Caves are particularly good places to see structure. On the Grottoes, Virginia, geologic map produced by Gathright, Henika, and Sullivan for the Division of Mineral Resources, an accurate but confusing array of dips and strikes is denoted on Cave Hill. The then-known cave passages on the hill added to this confusion. While the bedding in the commercial section of Grand Caverns is near vertical, the dip angle of the bedding in Fountain Cave, immediately south of Grand, is approximately 35 degrees.

In the fall of 2004, new passage was opened in Grand Caverns. Among the discoveries was a room, Kentucky, that at its longest dimensions is 800 feet by 260 feet. The strata in Kentucky go from moderately south dipping in the east to near vertical in the west. Cross bedding and flute casts point west as up-strata, indicating that we were in the eastern limb of an inclined anticline. Pressure solution cleavage is well developed, especially near the fold axis and in the steep limb leading to that axis. The pressure solution cleavage is oriented roughly parallel to the inclined fold axial plane, suggesting that the structures are contemporaneous and that the rock was deformed under moderate temperature and ductile conditions.

The discovery of Kentucky unifies the disperse dips and strikes previously measured on Cave Hill into a single structure, an inclined anticline running oblique to the hill's escarpment.

GROUND WATER TRACING RESULTS IN THE ALMAVILLE/BLACKMAN COMMUNITIES, RUTHERFORD CO., TENNESSEE, TO AID IN EMERGENCY SPILL RESPONSE ALONG I-840

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Eleven ground water (dye) traces were performed in one of the fastest growing areas of Rutherford County along the Interstate Highway-840 corridor near its intersection with Interstate Highway 24. When possible, the dyes were injected into sinkholes within, or in close proximity, to cloverleaves where trucks are more prone to turn over and spill hazardous materials. The research results have made possible the delineation of three spring basins. Nearly 15 kilometers of interstate highway and other major highways are now known to drain to these springs. In addition, some of the tracing results, added new information to ground water flow from the 15 kilometer long Snail Shell Cave system. Nick Crawford conducted traces nearly 15 years ago from Snail Shell Cave to Walker Spring located along the West Fork of the Stones Rivers. Four of the new traces conducted by the authors split and emerged at both Asbury Spring and Military Spring, which are located significantly up-gradient and several kilometers away from Walker Spring. Thus, the research results show that

Asbury and Military Springs are high-level overflow springs and hydrologically connected to Walker Spring.

THERMAL BEHAVIOR OF EARTH CAVES AND POSSIBLE CAVE-LIKE STRUCTURES DETECTED ON MARS

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We have demonstrated caves on Earth may be detected using thermal imaging. From study of caves in western New Mexico, northern Arizona, southern California and northern Chile, we collected and analyzed ground-based hourly temperature data, ground-based thermography, and thermography via fixed wing aircraft and hot air balloons. Through this work, we have gained insights into detection of terrestrial caves in the thermal infrared. There are diurnal and seasonal temperature variations, and caves are most detectable when the temperature contrast between the entrance and ground surface is greatest. However, geological and structural aspects of caves and surrounding surface may affect thermal behavior and thus detectability. We are applying insights and lessons learned from Earth caves to explore the feasibility of using orbiter-based thermal imagery to detect caves on the Martian surface. Preliminary analyses of visual and thermal imagery have revealed possible cave-like structures in several regions on Mars. Many of these features have thermal characteristics similar to some of our terrestrial sample sites. While it is inconclusive whether these features lead to subterranean passage into the Red Planet, these results are compelling and warrant further research.

EVOLUTION OF THE KARST AQUIFERS OF THE SHENANDOAH VALLEY, VIRGINIA AND WEST VIRGINIA

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The Shenandoah Valley is underlain by a substantial thickness of Cambro-Ordovician aged carbonate bedrock. The karst topography is complex, with sinkholes, caves, and springs more common near base level streams. Larger, calcium saturated springs commonly occur at elevations up to 50 meters above these streams, with spring runs commonly captured by vadose cave passages before emerging near modern base level. Transitional zones separate the perennial springs from current base level drainage network that divided the valley into smaller, hydrologically distinct blocks. Dye traces within block interiors yield long travel times, high dilutions, and divergent flow. Dye traces in transition zones show short travel times, little dilution, and convergent flow.

Patterns of genetic divergence between populations of the Madison Cave Isopod, *Antrolana lira*, suggest that populations, once in genetic contact via migration through a more extensive karst aquifer could have become isolated via stream incision. High levels of genetic divergence for mtDNA (COI) (9.5 – 11.2%) indicate that isolation occurred roughly 7 ±

3 ma, based on a mutation rate of 1.25% per my (Ketmaier, 2003). *Antrolana lira* shared a common ancestor with *Cirolanides texensis* approximately 20 ± 7 ma, suggesting colonization by *A. lira* occurred during the Miocene sea-level high stand.

These two lines of evidence are consistent with a history in which the Shenandoah Karst is the eroded remnant of a regionally extensive aquifer much like today's Edwards Aquifer or the Yucatan. *Antrolana's* marine lineage suggests that a saltwater-freshwater interface may have influenced aquifer development.

THE KARST INFORMATION PORTAL (KIP): DEVELOPING A NETWORK OF GEOGRAPHIC AND GEOLOGIC KARST INFORMATION.

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The difficulty of sharing geologic and geographic karst information is well documented. While there is a significant body of internationally accessible literature, important works are largely unknown or inaccessible. Some of the more difficult documents to access include maps, databases, technical reports, graduate theses or dissertations, images, video, and government publications. Also, karst related documents published in less-accessible languages are hard to access or find—especially those published prior to the information age. In order to address this issue, the Karst Information Portal (KIP) was formed in 2005 and launched in 2007. KIP is an evolving international community of scientists, information specialists, and other researchers seeking to promote information sharing and access to published and unpublished research in order to advance karst, cave, and aquifer research and stewardship. The portal is a searchable database of a variety of karst information that is accessible anywhere in the world. Like other well-known portals, such as Chronos, the KIP will continue to grow as users and developers bring more information within the network. We seek to expand KIP by developing partners to populate the portal with pertinent databases, maps, gray literature, and other information of interest to the geoscience community. The KIP has the potential to transform geologic and geographic research in karst by creating new knowledge through the integration of international information in the discipline.

LATE HOLOCENE PALEOENVIRONMENTAL CHANGES: EVIDENCE FROM CAVE SEDIMENTS IN FLORIDA

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Cave sediments collected from Jennings Cave in Marion County, Florida show $\delta^{13}C$ variations in their organic acids, which indicate periods of vegetation change caused by climatic influences during the Late Holocene. The carbon isotope record ranges from -35‰ to -21‰, exhibiting variability of ~14‰, which is within the range of C3 vegetation. This is to be expected in a humid, subtropical forested environment, and likely indicates changes in C3 plant abundance. The most negative $\delta^{13}C$ value of ~ -35 percent occurred around 1,870 cal yr BP, sharply

becoming less negative to -21% around 1,800 cal yr BP. These changes in plant assemblages were in response to changes in available water resources, with increased temperatures and evapotranspiration leading to arid conditions and a shift toward less C3 vegetation (increased C4 vegetation) during the Medieval Warm Period. The cave sediment $\delta^{13}\text{C}$ record agrees well with $\delta^{13}\text{C}$ values from a speleothem collected nearby that covers the same time period. Prolonged migration of the Intertropical Convergence Zone and North Atlantic High affects precipitation in Florida and likely caused vegetation changes during these climatic shifts.

DETERMINING THE SENSITIVITY AND DISTURBANCE OF TERRESTRIAL CAVES IN WEST-CENTRAL FLORIDA: AN INVENTORY OF PUBLIC AND PRIVATE CAVE SYSTEMS

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One of the most significant and extensive karst terrains found throughout the world is in Florida. Cavernous systems found here are dynamic natural resources that are affected by surface and subterranean environmental changes. Moreover, the management of caves presents a number of challenges given the non-renewability of cave contents and the environmental sensitivity of caves to anthropogenic disturbances. An ongoing inventory is being conducted in terrestrial caves on both public and private land in west-central Florida. The goals of this inventory are to determine what relationships exist between cave sensitivity, human disturbance in caves, and land use, as well as ensure the preservation and protection of any non-renewable resources by establishing which caves necessitate management plans due to their high sensitivity levels. The inventory includes data at each cave survey station on entrance and passage characteristics, geological, hydrological, cultural, biological, special interest, and human disturbance areas in each cave. Hierarchical scales are used to determine the amount of human disturbance and relative sensitivity of each cave included in the inventory. To date, 30 caves have been inventoried throughout the west-central Florida karst landscape: 15 located on public, state-owned land and 15 located on private land. Data was collected *in-situ* and revealed that the majority of caves on private land should be classified as "significant" and are less disturbed than caves on public land. However, some caves located on public land should be classified as "significant," yet most were found to have high levels of human disturbance.

THE EXTENT AND TIMING OF A PRE-LATE WISCONSINAN ICE MARGIN IN CENTRAL INDIANA: A NEW VIEW FROM GLACIAL-LACUSTRINE SEDIMENTS FROM PORTER CAVE

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Evidence for proglacial lakes in central Indiana has been well documented for over 100 years. These laminated sediments intercalate with glacial tills, loess and paleosols and record the advance and retreat of the Illinoian and Wisconsinian ice sheets. Karst and associated caves found within the mapped margins for the late Quaternary ice sheets have been previously suggested as high-stand outlets for these lakes. Glacial Lake Quincy, the oldest stratigraphically of the lakes in the Mill Creek area in central Indiana partially overlies karst terrain. Some caves in this area contain an abundance of glacial-lacustrine sediments and are associated with many mid-drainage waterfalls and under fit valleys reflecting a complex glacial history. A critical discovery is the ubiquitous presence of well-preserved proglacial lake sediments within Porter Cave that contain organic material ideal for radiocarbon dating and sediments amenable for optically stimulated luminescence (OSL) dating. Previously reported borehole records indicate that lake sediments were over run by the advancing ice margin subsequently depositing a glacial diamicton.

We report the first quantitative chronologic control derived from ^{14}C and OSL ages on Glacial Lake Quincy sediments within Porter Cave. Those data

indicate the formation of Glacial Lake Quincy about 30 to 45 ka in the paleo-Mill Creek coincident with the Roxana Loess deposition in the Midwest. Mapped ice sheet margin associated with common waterfalls and distribution of lake sediments indicates that the ice sheet margin during marine oxygen isotope stage-3 was similar in extent to the last glacial maximum.

HOW DOES OUTSIDE TEMPERATURE INFLUENCE INSIDE TEMPERATURE IN FOCUL VIU ICE CAVE IN ROMANIA?

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The purpose of this study is to evaluate the influence of outside temperature on cave air temperature in Focul Viu Ice Cave in Romania. The cave is located in the central part of the Bihor Mountains, Romania, at an elevation of about 1200 m asl. It is a 700 meter long descendent cave that hosts a 25,000-cubic-meter ice block at its bottom. Between April 5, 2004, and April 4, 2005, air temperature was continuously recorded with one hour interval in three points inside the cave and one point outside of it. Using regression statistical analysis, we identified the best model fit to describe the relationship between external and internal air temperature variations. In this model, the quantitative variables are represented by the air temperatures outside and inside the Great Hall in Focul Viu Cave; while the qualitative variables are represented by the seasons (Spring, Summer, Fall and Winter) and times of the day (Morning, Afternoon, Night). The collected data show a strong correlation between the external and the internal air temperature as long as outside temperatures are below 0°C (generally during winter, when rapid inflow of cold air in the cave occurs). In summer, the presence of the ice block maintains internal air temperatures close to 0°C , thus no air exchanges are observed between the outside warmer and lighter air masses and the colder and heavier internal ones.

APPLYING THE KARST DISTURBANCE INDEX IN WEST-CENTRAL, FLORIDA

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A hierarchical and standardized environmental disturbance index, specifically designed for karst landscapes, was created by van Beynen and Townsend (2005). To assess the applicability of the index and provide recommendations for its refinement, the index was applied to four counties in West-Central, Florida. The karst disturbance index consists of 30 indicators contained within the five broad categories: geomorphology, hydrology, atmosphere, biota, and cultural. Data were readily available for most environmental indicators used to construct the index. Overall, levels of disturbance vary between the counties due to the level of urbanization, with the highly populated Hillsborough-Pinellas having higher degrees of disturbance than less developed Pasco-Hernando counties. While this result may seem obvious, the measure of disturbance using many indicators provides benchmarks of levels of disturbance that can be reassessed with time and highlights those aspects of the environment most in need of attention. However, several minor issues arose during the testing: the need for broader indicator descriptions that encompass a variety of scenarios, a new water quality indicator, obsolete data on sinkholes, and a lack of data for biota indicators. The lack of data for certain indicators suggests where future research efforts can be directed; for our region those include species richness and diversity changes in caves and urban groundwater quality.

HUMAN SCIENCES

CAVE DIVERS: A MIXED METHODS STUDY OF LIFESTYLE, PERSONALITY, AND PSYCHOBIOLOGY

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Cave diving is said to be the most dangerous sport. Why are these divers attracted to putting on 140 pounds or more of very expensive, complicated equipment and then swimming in an environment where the only breathable gas available is that which they carry with them? Cave divers seem to have unique personalities, as well as the ability to solve problems quickly and to survive in extreme environments. Since the 1960s more than 500 individuals have died in underwater caves. In the face of such great potential for personal and family loss, why do some people choose to dive in caves?

My research will be conducted in the summer of 2007 and features a blending of quantitative and qualitative approaches. The mixed methods design includes three online test instruments: the Adlerian Lifestyle Assessment, Zukerman-Kuhlman Personality questionnaire, and Family Assessment Measure III. These tests will be administered to 100 cave divers during the initial phase. Later, 10 cave divers will be qualitatively interviewed to examine patterns of their family dynamics. These same ten divers will be DNA tested for polymorphisms of the D4DR and 5-HTTLPR genes. The long form of the D4DR gene may be linked to the Novelty Seeking Personality Trait and the short form of the 5-HTTLPR may be linked to anxiety behaviors. This research furthers the study of novelty-seeking, sensation-seeking, risk-taking behaviors, and personality development. Specific variables that will be measured include: Extroversion/Introversion, Sensation Seeking, Cautiousness, Control, Anxiety, Venturesomeness, Social Desirability, Creativity, Affective Expression, and Family Communication.

INTERNATIONAL EXPLORATION

WHAT ARE MARS ANALOGUE SITES AND WHY ARE THEY IMPORTANT IN THE SEARCH FOR CAVES ON MARS?

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Our ability to study the surface of Mars is still quite limited. Mars analogues are typically hyperarid, with wide diurnal temperature fluctuations, high ultraviolet radiation exposure, and are geologically similar to the areas on the Red Planet (for example, areas of surface basalt, dust, and the like.). However, rarely does any one site meet all these conditions. Thus, researchers study a range of sites, which are characterized incompletely by various suites of these conditions. We will discuss selected Mars analogue sites with documented speleogenesis or regions likely to contain caves here on Earth. These areas are of particular interest for developing techniques to locate caves on both Earth and Mars using thermal remote sensing imagery. We will also discuss the results of cave thermal behavior research at two premiere Mars analogue sites—the Atacama Desert of northern Chile and the Mojave Desert of southern California, and some possible cave-like structures recently identified on the Martian surface.

SISTEMA TEPEPA: RECENT PROGRESS OF THE MEXPE PROJECT

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The area of Sistema Tepepa (Puebla, Mexico) has been explored for the past 20 years by the Mexpe project of the Quebec Speleological Society (SQS). Sistema Tepepa is the second deepest through trip in the Americas and is now over 28 kilometers in length and 900 meters deep. Nearby

Sistema Brumas Selvaticas (8 kilometers), La Ciudad (6 kilometers) and 20th Anniversary Cave (3.5 kilometers) are awaiting a connection to Sistema Tepepa. Recent exploration took place in these four (and several other) caves during the 2006 and 2007 month-long expeditions. These productive expeditions (8 kilometers in 2006; 10 kilometers in 2007, for teams of 14 and 19 cavers respectively) took advantage of the latest cave surveying technology such as Auriga and electronic data acquisition devices. The area offers a mixture of boreholes, raging rivers, digs in tight blowing passages, breakdown mazes, and well-decorated passages, and there's plenty more to discover.

THE QUINTANA ROO SPELEOLOGICAL SURVEY: RECENT CAVE EXPLORATIONS IN QUINTANA ROO, MEXICO.

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The Quintana Roo Speleological Survey supports conservation, safe exploration and confirmed survey documentation of underwater and dry caves in Quintana Roo, Mexico. The present study area incorporates 6,300 square kilometers in eastern Quintana Roo; to include 676 kilometers of surveyed underwater passage, and 8 kilometers of surveyed dry cave passage

Current investigations in Sistema Sac Actun have succeeded in linking over 6 major underwater caves and one dry cave. Containing over 155 kilometers of passage, Sac Actun is the longest cave in Mexico and the longest underwater cave in the world. At this date, new explorations in Sistema Sac Actun are within 25 meters of Sistema Dos Ojos (58 kilometers in length).

Dry cave explorations proximal to a Pleistocene ridge are producing significant finds. Cave passage development is associated with both deeper underwater cave passages, and the initial upper level of the ground water table. Sump explorations within dry caves connect both dry and underwater caves. Connections between distant underwater caves through dry cave passage are under investigation.

SIX YEARS OF EXPLORATION IN CHINA

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Since its formation in 2001, Hong Meigui Cave Exploration Society has mapped over 270 km of cave and recorded over 1,000 entrances throughout south-west China. Expeditions have explored karst areas of Chongqing, Guangxi, Hubei, Hunan, Sichuan, and Yunnan. Highlights include:

- Extensive vertical development in Tianxing, including numerous 200+ m vertical shafts, the second biggest natural underground vertical drop in the world, a 491 meter-deep shaft in Miao Keng, and the four deepest caves in China: Tianxing Dongxue Xitong (19,025 m, -983 m), Dong Ba Dong (7,646 m, -649m), Da Keng (4,273 m, -775 m), Miao Keng (1,039 m, -681 m).
- Over 80 km of complex multi-level passage in Houping-Tongzi-Jielong, including the fourth and fifth longest caves in China: San Wang Dong (28,892 m, -300 m) and Er Wang Dong (25,320 m, -241 m).
- Over 65 km of classic cone karst and river caves in Nandan and Leye.
- The 200 m × 300 m Hong Meigui Chamber and some of the largest tiankengs in the world.
- The search for 2000+ m depth potential along the deeply-incised Jinsha Jiang (upper Yangtze).
- The longest and deepest conglomerate cave in China, Longmen Dong (13,190 m, -355 m).
- A new species of blind loach, *Triplophysa rosa*, and numerous likely-new undescribed species of springtails and millipedes.

With over 100 members from 13 countries, HMCES embraces high survey standards and openness with regard to data. Survey data, surveys, cave descriptions, and photos are all available at www.hongmeigui.net

TANTALIZING TONGZI, WULONG COUNTY, CHONGQING, CHINA

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In April 2007 a British and American expedition of the Hong Meigui Cave Exploration Society explored the karst and caves near Tongzi and Jielong in Wulong County, China. The team surveyed 15 kilometers and identified numerous new karst features, caves, and springs. Highlights of the discoveries include: Yan Tang Ping Dong, a tortuous, Charco-esque cave explored to -154 meters; Lao Chang Dong (Old Factory Cave), a 3,146-meter-long and 98-meter-deep cave complex, including old trails and miner's artifacts; Shang Hetao Wan Dong (Upper Walnut Bend Cave), the town dump, which was connected to nearby Leng Dong (Cold Cave), forming a 249-meter-deep, 4,865-meter-long system; and Quan Kou Dong (Spring Mouth Cave), a 116-meter-tall entrance with a 3.5 cumecs/sec stream and amazing airflow. Reconnaissance of a several kilometer-long, closed-valley in Jielong township yielded beautifully decorated Xiniu Dong (length 846 meters, depth 56 meters), San Cha Dong, (length 1,391 meters, depth 74 meters), and many more cave entrances and shafts that were not entered. The team also continued dye tracing efforts in the Houping/Tongzi/Jielong area to delineate groundwater flow paths. Excellent leads and caves remain to be explored during expeditions planned for spring 2008.

CAVES OF SARDINERA - ISLA DE MONA, PUERTO RICO

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Isla de Mona, an uplifted reef platform of Miocene and Pliocene age, is known for its world-class flank margin caves. The caves were formed at sea level within the carbonate platform and the largest have developed along the contact between the Lirio Limestone and the Mona Dolomite.

Caves have also been found in the Mona Dolomite, but they tend to be smaller and less complex. Caves are exposed at various elevations through a combination of tectonic uplift, glacio-eustatic sea level changes, and cliff retreat. Though caves have developed along the entire perimeter of the island, Playa Pajaros on the southeast side, and Playa Sardinera on the west side, display the highest concentration of cave development. Beginning in 2005, the Isla de Mona Project began working in the caves at and near Playa Sardinera. As with caves on the southeast side, the Sardinera caves are characterized by multiple cliff-side entrances and skylights, and large, mazy passages. Most of the caves contain remnants of historical guano mining operations, and evidence of use by the Taino Indians. Exploration and mapping are ongoing in Cueva Murcielagos, which contains the largest bat colony on the island, and in Cueva Esqueleto, which has some of the biggest cave passages and has been heavily mined for guano. There are numerous smaller caves located along the cliff-lines of Sardinera where some survey work has been completed, but there are many more to be found.

PALEONTOLOGY

THE KARST INFORMATION PORTAL: A VIRTUAL TOOL TO FACILITATE RESEARCH AND COLLABORATION IN PALEONTOLOGICAL SPELEOLOGY

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Data access, management, and evaluation challenge the progress of speleology. Crucial information is both scattered throughout specialty mainstream journals and buried in the gray literature. The karst-information problem is exacerbated in paleontological speleology due to overlaps with other disciplines, such as geology, biology, paleoclimatology, and hydrology, increasing the number of potential journals in which paleontological resources in caves may be published. Important patterns and relationships can easily be overlooked, especially when no geographic or cultural connections are known between paleontological sites within caves.

The Karst Information Portal (KIP) is a solution to these paleontological research problems. Conceived in 2005 and launched in June 2007, KIP developed as a partnership between the International Union of Speleology, National Cave and Karst Research Institute, University of New Mexico, and University of South Florida. Key features present or in development include:

- Federated (simultaneous multi-source) searches of Web sites to more efficiently and reliably locate key research papers and information;
- A searchable database of multidisciplinary karst information;
- A library of on-line papers, reports, and theses on karst related topics;
- A collaborative international on-line workspace to post and evaluate images, maps, databases, and other published and unpublished information.

Like other virtual research portals, KIP will grow as existing and future partners contribute information and connect websites and databases into the network. KIP will not duplicate existing databases but will serve to more efficiently access and process them with superior search tools. A cave paleontology bibliography is under development, but additional partners are needed to fulfill KIP's potential in revolutionizing paleontological speleology through its advanced and collaborative integration of data and ideas.

A GIANT SHORT-FACED BEAR (*ARCTODUS SIMUS*) FROM ISLAND FORD CAVE, VIRGINIAFred Grady¹ and Blaine W. Schubert²¹Department of Paleobiology, Smithsonian Institution, National Museum of Natural History, Washington, DC 20013, GRADYF@si.edu²Center of Excellence in Paleontology and Dept. of Physics, Astronomy, and Geology, East Tennessee State University, Johnson City, TN 37614, schubert@etsu.edu

The remains of an extinct giant short-faced bear (*Arctodus simus*) were recovered from Island Ford Cave, Alleghany County, Virginia, in the 1990s. This individual represents one of the most complete skeletons known for the species. The worn teeth, fused epiphyses, and small body size suggest it was an adult female, and the location in the cave and partial articulation of elements indicate it may have died while denning. Extreme examples of exostosis on the skeleton also attest to the advanced ontogenetic age of this individual. A radiocarbon date on dentine provides a geologic age of 34,080 ± 480 14C yr BP for the bear.

NEW FINDS FROM NEW TROUT CAVE, PENDLETON COUNTY WEST VIRGINIA

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Vertebrate remains are well known from New Trout cave, the first being reported during the 1979 NSS Convention. Work in 2006 resulted in the recovery of more than 200, 10-pound bags of bone bearing matrix, mostly from the main site. Most of this has been processed by screening. Two species not previously known from New Trout have been recovered from the main site, a single tooth of the river otter, *Lontra canadensis* and two maxillae and one mandible of the least chipmunk, *Tamias minimus*, a mid-western species. This latter species was previously reported erroneously from New Trout. Other rare taxa recovered from the main

site include the gopher, *Geomys sp.*, pika, *Ochotona sp.*, and extinct vampire bat, *Desmodus stocki*. From Site 3, teeth of a small extinct muskrat, *Ondatra hiatidens*, indicate a much earlier age than previously thought, being on the order of 500,000 years before present. Additional remains, including two mandibles, of *Geomys* were also found in Site 3.

SPELEAN HISTORY

CAVE ART IN CAVE HISTORY: A GLOBAL CONSIDERATION

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New interpretations of European cave art and new recognition of its North American counterparts open windows into the role of cave art in cave history worldwide. In a speleocentric viewpoint, interfaces exist between cave art and rock art, and between cave art, historical inscriptions, political assertions, and graffiti. However artificial religious grottoes, recreational ("garden") grottos, meditation grottos, and burial grottos are architectural features, not caves. On a global basis, cave art may be classified as cave paintings (including pictographs), cave sculpture (including petroglyphs and mud glyphs) and manuport art (including religious statues, ornate chandeliers, and the like). Age and motivations reflected in existing cave art vary widely but each type contributes to the history of individual caves and their regions. Examples are presented from the eastern and western United States, eastern and western Europe, Mesoamerica, Venezuela and the Caribbean, Africa, India and Ceylon, China and southeast Asia, Australia, and Hawai'i.

THE CAVE CURE: OLD AND NEW IDEAS ON THE HEALING PROPERTIES OF CAVES

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Caves have long been associated with mystery, fear, and good health. Crushed stalactites were used in ancient China and 17th century Europe as sedatives, cough medicine, and to heal broken bones. In the 19th century, visitors at Mammoth Cave thought the cave air enabled people to walk much farther without fatigue than they could above ground. In the 1840s, tuberculosis patients were even housed in Mammoth Cave to take advantage of the healing properties. Even today, caves and mines in eastern Europe and Montana are visited by sick and injured people hoping to be cured by the radon or salt ions. Are visitors healthier because of the radon and ions they absorb? Exercise from caving is a health benefit, but don't expect to be cured of tuberculosis or other illnesses on your cave trips.

THE DISCOVERY OF THE FIRST CUBAN BLIND CAVE FISH: THE UNTOLD STORY

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The first two species of blind cave fishes described in the scientific literature from outside the United States were from Cuba and their description was published in 1858. They were the Cuban cusk-eel *Lucifuga (Lucifuga) subterranea* and the toothed Cuban cusk-eel, *Lucifuga (Stygicola) dentata*. The description of those species was published by Felipe Poey, a Cuban lawyer turned naturalist. The original documents that relate the discovery of these species were recently found. Those documents reveal a complicated saga of events but show that those fishes were actually seen for the first time in 1831, 11 years before the publication of the first scientific description of a blind cave fish: the northern cave fish *Amblyopsis spelaea*, from Mammoth Cave, Kentucky. Poey relied on others to collect the blind cave fishes in Cuba. His anatomical and taxonomic analyses of these specimens were highly accurate, and these fishes helped to convince him to embrace the idea of evolution. He kept ample correspondence with contemporary colleagues from the U.S. and Europe and most likely sent the specimens he used for

describing the two species of Cuban blind cave fishes to museums abroad, particularly the National Museum of Natural History in Washington, D.C. and the Museum of Comparative Anatomy at Harvard University.

THE HISTORICAL GEOGRAPHY OF SHOW CAVE DEVELOPMENT

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Show cave histories tend to focus on the sequencing of events that occurred at specific caves, researched and written independent of other caves. Historical geography, with its emphasis on spatial patterns through time, provides a perspective on cave commercialization for an entire region. Emphasizing commercial caves in the eastern United States, a set of periodic stages are presented as a national model for the historical development of show caves. Beginning in the 19th century and continuing to the present, the pattern of tourist cave development is related to the evolution of transportation systems and the changing interpretation of how entrepreneurs should present caves to the paying public.

HISTORY OF ALLENS CAVE, WARREN COUNTY, VIRGINIA

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Allens Cave is located near Front Royal, Virginia. The cave may have been known as early as 1774. It is shown on Charles Varley's *Map of Frederick, Berkeley, and Jefferson Counties in the State of Virginia*, published in 1809. In 1835, Joseph Martin published *A New and Comprehensive Gazetteer of Virginia*, in which there is an extensive detailed and surprisingly accurate description of the entire cave. In the mid-1930s there was apparently an attempt made to commercially develop the cave. This endeavor moved to the adjacent Skyline Caverns when it was discovered in 1937. Allens Cave was described in NSS Bulletin Number 2, in 1941, and was a frequent destination of cavers from the Washington area during the 1950s and 1960s. Due to vandalism and possible liability, the cave was sealed in the early 1970s, and remained so until the late 1990s, when it was re-opened to investigate its proximity to a potential highway widening project.

The cave is known for its large Ballroom, said to have been the site of social gatherings over the years. The walls of the room, and of many other of the passages, are covered with names. Recent examination of the walls has yielded the names and unit identifications of Confederate soldiers, apparently placed there following the Battle of Cedar Creek, in October, 1864. The walls of the cave also exhibit the names of some cavers, which is a measure of how our understanding of cave conservation has evolved over the years.

SOME LITTLE KNOWN EPISODES AT WYANDOTTE CAVE, INDIANA

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Wyandotte Cave has a long and storied history, becoming a show cave in 1850. There were also visits by prehistoric Indians thousands of years prior. Oddly, the Indian group for whom the cave is named probably never set foot far inside. There are many other aspects of the cave that are either little known or just recently coming to light. Throughout the years the cave has been the site of suicide, windstorms, and early billboard advertising, of which little is known or written. Some of the cave's stories exist as folk tales, featuring lost passages, hidden underground rivers, and a supposed purchase by P.T. Barnum that never occurred. Monument Mountain was featured by Ripley's *Believe It or Not* in 1932, gaining national prominence for the cave. Presidents, governors, geologists, filmmakers, astronomers, and other famous people have visited the cave from time to time. One of the more curious incidents occurred in 1941 when a team of mules was led several thousand feet into the cave to excavate a newly found passage for tours. The cave is currently the site of scientific research, including a study of the major Indiana bat hibernacula and a working seismograph.

SPRINGHOUSES IN KENTUCKY: FORM AND FUNCTION IN AN EVOLVING CULTURAL LANDSCAPE

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Natural springs are characteristic features of karst landscapes and have been highly valued as water supply sources from prehistory to the present day. Springs are frequently modified to improve accessibility, increase flow, and to protect the discharge point. Spring modifications constructed in an earlier era are often maintained, renovated, or improved by later generations. Kentucky provides an exceptional study area in which to investigate the significance of springs upon the cultural landscape. The importance and use of springs from the earliest days of settlement and exploration are amply documented in the historical record, and springs in both highly modified and undisturbed states may be found. The author has documented and photographed nearly 1,000 springs within the state, focusing primarily upon the Inner Bluegrass karst region. The purpose of this study is to investigate the nature and variety of spring modifications in this region, their origins and distributions, their relation to settlement patterns, and their changing significance in relation to changes in land use and cultural context. A classification hierarchy for spring modifications was developed for this purpose.

USING HISTORICAL ARCHIVES TO DISCOVER FORGOTTEN CAVES

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Cave entrances, and even entire caves, can be "lost" when knowledge of their location or existence fades from collective popular knowledge. Caves disappear as a result of natural processes or human activity that may disguise, cover, or even destroy these features. Frequently, however, significant karst features have been documented in some manner, and the task of the researcher interested in locating such features becomes that of discovering obscure references within the vast array of archival materials. In the past, human society has generally attached more significance to springs, as invaluable sources of water and power, than to caves, most often considered as curiosities with little value other than a few folk usages. Accordingly, archival material tends to refer more to springs than to caves per se; but in karst terrains springs are often indicators for cave systems. This paper describes and evaluates some of the primary archival sources for locating information about forgotten caves, and provides illustrative case studies from the Inner Bluegrass karst region of Kentucky.

STATE CAVE SURVEY

WEST VIRGINIA SPELEOLOGICAL SURVEY

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The West Virginia Speleological Survey was founded in 1967, after it became evident that the West Virginia Geological Survey had no plans to update William Davies' *Caverns of West Virginia*. WVASS' purpose is the collection and dissemination of cave and karst data, the stimulation of cave and karst research, and the protection of caves in accordance with the policies of the National Speleological Society.

To that effect, WVASS has produced, beginning in 1971, 18 publications. At present, we have 19 directors, who assimilate the data for approximately 20 areas throughout the state. Active areas of work in West Virginia include Greenbrier County, Shavers Mountain, Germany Valley, and Grant County. We are attempting to produce seven additional publications in the near future, including works on Monroe County, Culverson Creek, Grant County, the Western Slope of Greenbrier County, Pleistocene paleontology, saltpeter caves, and vertebrate fauna.

WVASS also maintains a significant cave list, which comprises 11 categories and contains about 200 caves at present, and we have on-line reporting so that any caver can report or update their discovery. WVASS does not have a fixed membership, but any interested individual is welcome to attend our meetings and participate in our organization. We have two meetings a year: one in the fall at Old Timers, and another in the spring at a location that varies throughout the state. The Executive Director of WVASS is Bill Balfour, who can be contacted at 304-497-0859 or bal4karst@hotmail.com, url: . Our Web site is <http://www.pipeline.com/~caverbob/wvass.htm>.

TEXAS SPELEOLOGICAL SURVEY

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The Texas Speleological Survey (TSS) was loosely organized in 1961 to compile available information on Texas caves and to publish as much of that information as is possible and prudent. The TSS is now a non-profit organization existing on monetary donations, material donations and in-kind donations of labor. Book sales, including shipping and handling, are somewhat better than a break even proposition. Our mission statement, *Texas cave and karst data collected and organized to support science, education, conservation and exploration*, expresses our long term goal and commitment.

Affiliated with the Texas Memorial Museum, the TSS has offices at the University of Texas Research Campus in north Austin. Monthly work sessions provide a forum for interested parties to visit the office, investigate both paper and electronic files and contribute some labor. It has no members, or rather, all cavers are members, but has a volunteer Board of Directors who vote on business matters and assist in publishing, archiving cave files, and office maintenance. The Board has up to a dozen members at any given time. Associates are selected and used ad hoc to organize county files and to carry out specific operational tasks.

Data on paper and electronic form covers over 4200 caves, 1500 sinkholes and karst features, and Texas springs. Data requests, both casual for cavers and formal for managers such as scientists, environmental services, and state agencies, are handled electronically. Our Web site: <http://www.txspeleologicalsurvey.org/> posts publications for sale, has contact information, and provides links to other Web sites.

KENTUCKY SPELEOLOGICAL SURVEY

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This year's session topic is membership. The mission and goal of the Kentucky Speleological Survey (KSS) is "To preserve cave and karst data for the Commonwealth of Kentucky."

The KSS is a kind of library of cave and karst related data for the state of Kentucky. To fulfill this mission the KSS welcomes as members any individual or organization, such as a grotto, who would like to join. We ask that a membership form be filled out and submitted with a small fee. Elected directors from the organizations, as well as two directors at large, plus members of the board are eligible to vote on KSS business. In addition, all members, individuals, or organizations agree to the following:

- Must agree to the goals of the KSS
- Must agree not to divulge data held by the KSS
- Membership is not limited to Kentucky residents and the organizations can be out of state.

Membership shows that you support the goals of the KSS. The KSS holds four meetings a years at different locations across the state. Elections are held at the January meeting. In addition, paper caving sessions are conducted at Lexington four or more times a year. All members are welcome to these meetings and sessions. The KSS is a volunteer organization and we welcome new members to join, get involved, and make suggestions and improvements. As a matter of history, Kentucky cavers had not been organized on a statewide basis before the KSS was formed in 2001.

SURVEY AND CARTOGRAPHY

ROUNDRIPPING A DIGITAL MAP OF DRY CAVE WITH WALLS AND ADOBE ILLUSTRATOR SOFTWARE

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Cave cartographers commonly face the problem of adjusting cave maps to changes in survey data such as loop closures and additional survey. To avoid this problem, many cartographers wait to draft a cave map until after the survey project is finished. This results in maps not being available for ongoing survey, and occasionally never being completed.

Roundtripping solves this problem by registering digital cave maps to the digital survey data. This process involves exporting digital lineplots of cave survey data using WALLS cave data management software as a Scalable Vector Graphic (SVG) document. This SVG document is opened in Adobe Illustrator where walls, detail and other map elements are created in specific layers and then saved as an SVG. When new survey data or data changes are made to the survey data in WALLS the SVG modified by Illustrator is adjusted by WALLS so that the map elements will conform to the new survey data.

Dry Cave in the Guadalupe Mountains of New Mexico is an excellent test of the roundtripping process for drafting digital cave maps. Dry Cave is an extremely complex maze cave with many loops and at least five levels. The cave map is divided into five separate maps by level using WALLS. These Dry Cave level maps are updated after each survey trip using the roundtripping process with excellent results. Over 8.9 kilometers (5.5 miles) of survey have been drafted using the roundtripping process.

OPEN DATA: SMALL CAVES EXAMPLE TO PRESERVING DATA ON THE INTERNET

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A recent look into my file cabinet revealed a sobering fact. Of the many data sets I had, a large number were from cartographers or surveyors that were no longer caving, and in some instance no longer had any links to the caving community. In several cases I was the only one with the data to undrawn caves. What would happen if I were to lose these data, either from catastrophic events, or plain indifference? Likewise, what happens to data when a caver passes away, and the family or spouse have no idea what to do with all those muddy notes?

Large cave projects are actively saving and distributing notes and work to make sure nothing is lost. I will share a similar proposal for small caves that uses the Internet to store and distribute data that can increase access, distribute projects, and warehouse, and backup data for an extended period of time.

USING CAVE RADIOLOCATIONS AS A CONTROL GRID FOR THE CAVE SURVEY IN A LARGE CAVE SYSTEM

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Virtually all of the known portions of Jewel Cave have been mapped since 1958. This consists of over 224 kilometers of passages, lying beneath approximately three square miles surface area. Most of the cave has been surveyed with Brunton and tape, but the park is now regularly using Suunto and Disto laser meters. The survey has over 24,000 stations with 423 loops.

Because the farthest point of the cave is nearly 11 kilometers of survey from the nearest entrance (the elevator), subsurface loop closures are not entirely adequate for determining the accuracy of the survey.

Consequently, the park has employed a variety of cave radio location techniques to correct for survey error. There are currently 38 radiolocated points that have been tied into a surface survey and/or GPS locations.

Although this technique has its limitations, the errors are less than could be obtained with a subsurface survey, so the radiolocations are used as control points to correct the cave survey. This allows the park to make management decisions based on a high level of certainty of geospatial relationships between surface and cave features.

U.S. EXPLORATION

THE WEBSTER CAVE COMPLEX SURVEY GROUP (WCCSG)

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The WCCSG is dedicated to the exploration and survey of the Webster Cave Complex, Breckinridge County, Kentucky. Nestled in Sinking Creek Valley, surrounded by the 800-foot-high ridges, are the three known entrances of the Webster Cave System. The system is the longest of a dozen or so caves that make up the Webster Complex. The main trunk of this cave, thought to be one of the largest continuous trunks in the state, is over three miles long, 40 feet high, and more than 40 feet wide. In places, continuous lakes extend for over a half-mile with neck deep water from wall to wall.

Recently, the WCCSG has undertaken the challenge of resurveying and extending the known caves of the area, beginning in May, 2005. Currently surveyed at over 5 miles (including about 1 mile of newly discovered passage), the main cave survey is expected to net many additional miles. Many long leads remain unexplored.

This system contains a large river at its terminus and the source and resurgence of this water are not known. The potential for additional cave discovery in surrounding ridge areas is an impetus for continued work in the system.

SIX MILES IN SIX YEARS: THE EXPLORATION AND SURVEY OF JUGORNOT CAVE, PULASKI COUNTY, KENTUCKY

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Exploration and survey of Jugornot Cave in Pulaski County, Kentucky, resulted in approximately 10 kilometers of cave passage during a six-year period that began during the winter of 2001. Long-known under another alias, Old Kentucky Cave, Jugornot follows the nomenclature of the Dayton Area Speleological Society, who in 1974 surveyed the 1.5 kilometers of historically-known cave.

Our subsequent survey of Jugornot has revealed a complex vertical maze than spans a 90-meter-thick sequence of limestone. Passages are confined to a 50-meter-wide band that aligns along a fracture swarm associated with an ancient normal fault. The cave transects a ridge and conveys water from Jugornot Hollow into Pumpkin Hollow. Passages group into four principal levels and up to seven individual levels that are traceable over long distances. Since Jugornot is an entrenching canyon, these levels mark periods of quiescence when the level of the nearby Cumberland River remained stationary.

Wide passages partly filled with sediment and decorated with gypsum and epsomite characterize the upper two levels of Jugornot. The middle levels are smaller, less well defined, and often decorated by an array of speleothems. Vertical shafts up to 45 meters tall pierce the cave and transmit water to an active stream that occupies the lowest level. This stream penetrates a chert horizon and connects, via the Vindication Crawl, to the Pumpkin River. Airflow in the Vindication Crawl suggests significant cave beyond; however, determined efforts both upstream and downstream in the passage beyond have yielded less than 700 meters of survey.

CRYSTAL CAVE: THE RESURVEY OF WISCONSIN'S LONGEST CAVE

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Crystal Cave is Wisconsin's longest known cave, developed in the Willow River Dolomite, New Richmond Sandstone, and Oneota Dolomite members of the Ordovician Prairie du Chien Group. The cave was discovered in 1881 by William Vanaasse. At that time, the cave consisted of a sinkhole entrance dropping into a large room, with clay-filled passages extending from the main room.

After extensive excavation efforts, the cave was commercialized in 1941 by Henry Friede. The cave was purchased by geologists Blaze and Jean Cunningham in 1986. Since that time, Blaze and Jean have welcomed Midwest cavers in continuing the digging efforts in the cave, as well as other small caves in the adjacent valley.

Crystal Cave had been surveyed by a number of Midwest cavers through the years, but no comprehensive map of the cave was ever produced. In 2005, John Lovaas and Dawn Ryan began a resurvey of the cave using current cave survey techniques and tools. To date, they have surveyed 3,672 feet, and with digging ongoing in the Tree Fork Section of the cave, they expect to find more.

The completed map of the cave will prove to be a useful management tool for the current and future owners of the cave, as well as a research and study tool for speleologists.

CULVERSON CREEK CAVE SYSTEM, WEST VIRGINIA

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Culverson Creek basin in Greenbrier County flows from a 42-square-mile, closed karst and into the Culverson Creek Cave System at the base of a steep escarpment.

The 20.1-mile-long cave system has seven entrances, large passages, numerous streams, and plenty of challenges for exploration. A trunk passage extends from the main entrance for more than a mile and a half before being blocked by The Log Jam, where hundreds of saw logs and trees, some 75 feet in length, block the passage. Along the way logs have jammed across the passage 60 feet above the stream.

In the early years of exploration the system included three separate caves; Culverson Creek, McLaughlin, and Fullers. Each of these caves reached a section of the main Culverson Creek stream, but connection along the trunk was blocked by impassable sumps and constrictions. Connection of the system was knitted together along other passages and by-passes. The furthest downstream penetration—3 miles from the Culverson Creek resurgence—reaches a deep sump called Dream Lake, which has not yet been successfully dived.

Much of the cave floods during wet weather. Sediment deposits more than 100 feet high have inspired names like Mudderhorn and Mud Everest. Other names such as Death Canyon, Psycho Siphon, and Dread Pool are indicative of the challenges this wet cave system offers.

The potential for flooding, and the rapid response to surface weather, makes accurate weather forecasting essential for continued exploration.

IF YOU SURVEY IT, THEY WILL LET YOU IN: THE GOLIATHS CAVE SURVEY MINNESOTA

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Goliaths Cave, formed in the Ordovician Dubuque and Stewartville Formations, is located in Fillmore County, Minnesota. It is situated within the Jessies Grove/Cherry Grove blind valley, which is approximately 25 acres in size.

Goliaths Cave was first described as Coon Cave sometime between 1955–57 by members of the Niagara Cavers, a group of Midwest cavers and cave guides from Niagara Cave, Minnesota. They explored approximately a quarter of a mile of the cave.

Extensive backflooding from the cave would close the sinkhole entrance regularly, and exploration in the cave did not resume until 1980. Poor caver/landowner relations caused the cave to be declared “off limits” in 1988.

In 1999, the landowners sold the blind valley to the Minnesota Department of Natural Resources' Scientific and Natural Areas division. The entrance of Goliaths Cave was gated, and cave access was through a permit system.

After learning about the cave through historic exploration reports, John Lovaas and Dawn Ryan submitted a permit proposal to conduct a survey and inventory of the cave. The project consists of three components—survey, inventory, and stratigraphy. This permit proposal, approved in 2006, was the first proposal ever submitted to the Minnesota Department of Natural Resources for entry into Goliaths Cave for research or scientific purposes. The natural entrance is extremely flood prone, and monthly survey trips are run only when there is no threat of rain in the forecast. To date, they have surveyed 1,236 feet of cave passage.

RECENT EFFORTS OF THE CALIFORNIA SEA CAVE SURVEY

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After several years of inactivity we've seen some renewed sea cave survey along the California coast. This has been centered in two areas:

Mendocino County has numerous unmapped caves and a rugged, rocky coast that is often characterized by rough seas. In the early 1990s, Derek Hoyle and I surveyed two large caves, Cave of the Lost Soles (467 feet long) and Peters Creek Cove Cave (412 feet). On a trip in 2003, we mapped a series of caves on the south shore of Peters Creek Cove, and began work on a cave with a huge collapse pit entrance. Little River Pit was finished up on a second trip and proved to be 80 feet deep and 150 feet across, providing a back door entrance into a cave 365 feet long. We surveyed another littoral sink cave on the Mendocino Headlands and discovered another on California Coastal Project images, a great asset to sea caving.

In May 2006 we spent five days on Santa Cruz Island, scouting and surveying new caves we'd located since publication of my book on the island caves (*Sea Caves of Santa Cruz Island*, 1988). One of them, Hidden Fissure Cave, was 240 feet long, developed on a fault that had fractured an 80-foot-high cliff. The entrance was hidden behind a collapse. We scouted over two dozen more caves, but conditions were too rough to survey most of them. A fall 2007 return trip is planned, typically the calmest time of year.

EXPLORATION IN DRY CAVE 2005–2007, GUADALUPE MOUNTAINS, NEW MEXICO

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Dry Cave is an extremely complex, rectilinear, multi-level, maze cave located in the Guadalupe Mountains of New Mexico. The first documented trip to the cave occurred in 1933. Approximately 8 kilometers (5 miles) of cave were surveyed from the mid 1960s to the late 1970s. Many additional passages were explored but never surveyed during this time period and numerous unexplored leads exist.

A resurvey of the cave initiated in 2005 uses modern survey techniques such as backsights, detailed survey notes, and inventory. Digital cave maps are updated immediately after each survey trip, utilizing the Walls/Illustrator roundtripping process, and greatly aid further exploration and survey. In January 2006, this systematic cave survey resulted in the discovery of the McKittrick Avenue Section. More than 3.9 kilometers (2.4 miles) of cave have been surveyed in the McKittrick Avenue Section with many crawling leads remaining. The cave survey is currently up to 8.9 kilometers (5.5 miles) and should easily exceed 16 kilometers (10 miles).

Observations based upon exploration, survey, and cartography have shown that the major passages are aligned with the local bedrock dip. Strike oriented passages are often smaller but have proven to be the key to the discovery of extensive new areas. The cave appears to have formed in a dome-like shape that is wrapped around a topographic and geological

high point. Future exploration may reveal that cave passages completely surround this high point.

RECENT EXPLORATION IN LECHUGUILLA CAVE, NEW MEXICO

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Since the last NSS convention, nine expeditions have entered the cave. Survey and resurvey have taken place in all three branches. The 120th mile was reached in November 2006 on an expedition that surveyed more than 6,000 feet of virgin cave. In March 2007, Lechuguilla passed Holloch in Switzerland to become the fifth-longest cave in the world. Several of the recent expeditions have utilized low-impact technical climbing in order to discover new areas. Much of the new survey has been mop-up in boneyard maze areas, but other work has extended new sections found in the previous two years.

In the Western Branch, Chandelier Graveyard is being worked to remedy bad loops and bad sketches. Along the way, interesting new leads are being explored. Work continues in Southern Climes to define the edges of Hahd Coah Maze. Mother Lode has been resketched with several leads remaining. Widowmaker and Chocolate Factory continue to produce footage.

In the Southwest, continuing on the Flatlands breakthrough last year, four additional lead climbs were attempted. Three of the climbs were completed with minimal footage gained. The fourth climb remains a work in progress.

Three expeditions worked in the Near East to correct blunders and resketch large rooms. There were also two technical climbs attempted in this area.

In the Far East, one expedition discovered a new form of rusticle formation known as the Fence Wire. Another continued to explore Coral Sea in an area requiring multiple clothing changes in order to preserve pristine flowstone.

RECENT EXPLORATION AT JEWEL CAVE

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Since July 2007, over 3.3 miles (5.3 kilometers) of passages were mapped. All but half a mile (800 meters) was discovered on five multi-day trips to the southeastern section of the cave and in the western section of the cave, beyond the VACC. There were no breakthrough discoveries this year, but the total amount surveyed was greater.

Because of the climbing expertise of some of the explorers, more effort was made to climb ceiling leads; one above Seventh Heaven is particularly promising. A few pits have also been checked this year.

Much of the PC Junction area has been mopped up, with a good lower-level lead remaining. A long day trip to the southeast surprised everyone when one lead opened into a new area above the Volksmarch, with over a dozen leads yet to be mapped. Also, there has been renewed interest in the Western Motif area. Most of the work done there has been mop-up, but a tight lead with large cave beyond has yet to be surveyed.

With over 139 miles (223.8 kilometers), Jewel Cave is currently the second-longest cave in the world.

10,000 SINKHOLES AND CAVES: CASTILE KARST IN SOUTHEASTERN NEW MEXICO AND FAR WEST TEXAS

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Gypsum karst development is complex and diverse within the Castile Formation outcrop region of southeastern New Mexico and far west Texas, generally occurring in dense clusters. Large, steep-walled sinks dominate the landscape. Most sinks occur as highly-incised arroyos, but

near-vertical, collapse sinks are common. Caves are highly variable and diverse, ranging from small, morphologically simple features to large, morphologically complex and deep forms. Caves have been found with complete or partial development in laminated, massive, nodular, and tabular gypsum fabrics, as well as gypsum and calcitized evaporites.

Parks Ranch Cave is the best known and longest cave (6,596 meters) within the Castile Formation; however, recent exploration has made many significant discoveries. Crystal Cave has been extended to a depth and length of 93 meters and 669 meters, respectively. Dead Bunny Hole, which is developed in both gypsum and calcitized evaporite, was recently discovered and surveyed to a length of 420 meters with several leads remaining. Many newly discovered features have been pushed over 100 meters in length (for example, Bee Line Cave, Hassle Hole, and Birthday Cave). Two active stream caves have been documented (Brantley Stream Cave and Sinkhole Flat Stream System), as well as an isolated cenote-like feature (Cave Well Cenote). Recent exploration coupled with GIS-based analyses suggests that as many as 10,000 individual karst features (sinkholes and caves) occur within the Castile outcrop region.

UPDATE ON THE WIND CAVE SURVEY PROJECT, WIND CAVE NATIONAL PARK, SOUTH DAKOTA

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Since the last NSS Convention, the Wind Cave survey project has continued to document new areas of Wind Cave (as of 4/30/07). A total of eight Wind Cave Weekends have been held since the last Convention, where 3.08 miles were surveyed and inventoried during 44 trips. These trips averaged 369 feet of survey per trip and increased the official length of Wind Cave from 121.28 to 124.36 miles, maintaining its status as the fourth longest cave in the world. Except for the Gas Chamber (currently at 1,141 feet), the majority of new survey was in the interior of the cave. This exciting discovery, which is located on the southwestern edge of the cave, will be discussed in more detail in Carl Bern's talk, also being presented in the U.S. Exploration session. Additional survey was added to the two most extensive areas now being surveyed in Wind Cave, including the Ghost Town (currently at 4,637 feet) and the Mock October Room (currently at 3,625 feet). Another interesting discovery was the Flatlands, currently at 1,241 feet of survey. In addition to the new survey, a complete rewrite of the park's Cave and Karst Resource Management Plan has just been completed and is available as a PDF on the park's Web site. This plan establishes new policies governing the continued survey of Wind Cave. Additionally, the first ever Wind Cave Quadrangle book has also just been completed. This atlas contains 120 miles of cave survey drawn on 37 individual maps.

CHALLENGE AND POTENTIAL IN THE SOUTHERN COMFORT SECTION OF WIND CAVE, SOUTH DAKOTA

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Wind Cave, South Dakota, is one of the world's great maze caves. The Southern Comfort section was discovered in 1991 in a breakout from the 1- by 1-mile-square boundary that previously constrained the known cave. Since then, nearly 8 miles of survey have been documented in this section. Southern Comfort is a significant extension past the main body of the cave, and lies along the major axis of passage development. The geology of Wind Cave and environmental monitoring of nearby blowholes suggest that another breakout may be possible. Air movement can be felt in certain passages even in this remote section, and many leads remain to be checked. However, exploration and the push for another breakout face significant challenges in Southern Comfort. The network maze structure of Wind Cave makes it difficult to evaluate the potential of any given lead on the map, or in the cave. That structure also causes airflow to be weak, confusing, and possibly meaningless in guiding explorers to the best leads. Marathon day trips also present a physical and logistical challenge. A strong team that travels quickly to the exploration front may only be able

to devote 6 hours of a 17-hour trip to exploration and survey. Despite these challenges, 1.3 miles of new survey have been added to Southern Comfort since 2002. New strategies such as establishing a camp or bivouac might accelerate the pace of exploration, but would need to be weighed against impact on a National Park Service cave.

THE EXPLORATION OF CLAYSTONE CAVES IN WESTERN COLORADO

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Numerous caves have been found in sandstones and claystones of the Jurassic Morrison Formation and the Eocene Wasatch Formation in western Colorado. The largest, Anvil Points Cave, has over 650 meters of surveyed passage in a multi-level dendritic pattern. Many smaller caves in claystones have been found and documented on South Shale Ridge near DeBeque, beneath Cactus Park to the southwest of Grand Junction, near the Gunnison Gorge northeast of Montrose, above abandoned uranium mines south of Uravan, and south of Mesa, Colorado.

The caves are similar to those found in limestone in that they are seasonal conduits for streams, they divert water from one drainage to another, contain both entrance drops and internal pits, and have a variety of passage sizes ranging from very low crawls to passages up to 12 meters

across and over 8 meters high. Small crystalline, sulfate-based speleothems, including gypsum needles and thenardite, are found in the caves.

The caves are stable with walls and ceilings consisting of a hardened mud/rock matrix. Floors are either hard mud or sandstone bedrock. The caves occur in a variety of pseudokarst landforms containing dolines up to 50 meters across, blind valleys, resurgences, and vertical shafts up to 10 meters in depth. Surveyed lengths are usually in the 50–250 meter range with vertical extents up to 50 meters. Considering the areal extent of the Morrison and the Wasatch Formations and the number of caves found in cursory searches, there may be hundreds to over a thousand others.

URSA MINOR CAVE, SEQUOIA / KINGS CANYON NATIONAL PARKS, CALIFORNIA

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In August 2006 cavers discovered another wonder underground in Sequoia and Kings Canyon National Parks. Ursa Minor Cave abounds with large passages, beautiful lake beds, amazing formations, and other spectacular resources throughout its known extent. The cave length is now approximately 1,500 feet long with a number of leads still remaining.