

SELECTED ABSTRACTS FROM THE 2008 NATIONAL SPELEOLOGICAL SOCIETY CONVENTION LAKE CITY, FLORIDA

ARCHAEOLOGY

UNDER THE EDGE OF THIS WORLD: A PRELIMINARY INVESTIGATION OF DEEP CAVE EXPLORATION ON THE EASTERN HIGHLAND RIM ESCARPMENT, TENNESSEE

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As part of a larger project focusing on the prehistoric use of Tennessee caves, the author investigated the spatial, chronological, and environmental contexts of several deep cave sites located on the western escarpment of the Eastern Highland physiographic province, an area where little previous cave archaeology research has been conducted. Initial work involves documenting the human presence and discerning site function. Cultural features at four caves were observed, photographed, and their locations noted in relationship to cartographic information from existing (or new, specifically created) maps of the caves. Environmental factors both inside and outside the caves were examined, including entrance setting, geologic attributes, and the presence of culturally important resources such as gypsum. Results show a continuity of deep cave exploration over a long time span in the area, ranging from the Late Archaic to the Protohistoric period. Despite the presence of mineral resources, and suitability for other uses, preliminary research reveals only early exploration, not extractive, ceremonial, or other interactions. This confirms previous work suggesting exploration-only was the most common of all prehistoric cave usages in the Mid-South. A close examination of contexts as well as content provides the best framework for determining site function for caves.

BIOLOGY

COMPOSITION OF BACTERIAL MATS IN EL MALPAIS NATIONAL MONUMENT, NM: COMPARISON AND CONTRASTS WITH BACTERIAL COMMUNITIES IN HAWAII LAVA TUBES

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Cave bacterial mats cover walls of lava tubes around the world, including in New Mexico, yet little is known about their composition and role in the ecosystem. To address these issues, we undertook a study of the different colored bacterial mats in Pahoehoe, Four Windows and Roots Galore Caves, in El Malpais National Monument (ELMA), located to the southwest of Grants, NM. Previous studies in Four Windows Cave in ELMA, have revealed the presence of many members of the *Actinobacteria*, the group that produces many of the antibiotics in use today. To determine the composition of bacterial mats found in these three caves, and how they overlap with each other, we sampled bacterial communities found in the twilight and dark zones of each cave. DNA was extracted and purified, the 16S rRNA gene was amplified using PCR, cloned, and approximately 1400 bases were sequenced from clone libraries. Closest relatives were found using Ribosomal Database Project II and BLAST and a phylogenetic tree was constructed using PAUP. Comparison of Pahoehoe bacterial sequences with BLAST revealed that some were most

closely related to *Actinobacteria*, while other grouped with *Alphaproteobacteria*, and *Gammaproteobacteria*. Some overlap was found between clones from Four Windows, Pahoehoe and Roots Galore Caves, particularly within the *Actinobacteria*. There is less diversity in yellow bacterial mats than white bacterial mats, and this can be observed in the New Mexican and Hawaiian lava tubes. Our studies are shedding light on the nature of these communities and their possible roles in the ecosystem.

DISCOVERING NEW DIVERSITY IN HAWAIIAN LAVA TUBE MICROBIAL MATS

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Bacterial mats cover walls and ceilings of lava tubes around the world, yet little is known about their composition and role in the ecosystem or what controls their diversity. To address these issues, we ask: 1) What bacterial species are found in the mats? 2) Does diversity vary with respect to the different ages of lava flow? 3) Does species composition differ between differently colored mats? and, 4) What is the amount of organic carbon present in the drip water entering the cave system that can fuel heterotrophic growth? Samples were collected from microbial mats in eight different lava tubes found on the Big Island of Hawaii. Sampled mats ranged in color including yellow, white, pink, tan, and what appears to be an organic ooze. Samples were aseptically collected from each cave, and DNA was extracted and then purified. The 16S rRNA gene was amplified using PCR (~1365 bp), cloned, and then later sequenced. From this, closest relatives were found using the Ribosomal Database Project II and BLAST databases, and a phylogenetic tree was constructed using PAUP. *Actinobacteria* were found to dominate in most microbial mats, but not all. Other closest relatives were found to be *Cyanobacteria*, *Acidobacteria*, *Bacteroidetes*, *OP11*, *Chloroflexi*, and all divisions of the *Proteobacteria*. From our results we see a trend of less diversity in the yellow colored mats than in the white, while the greatest diversity was found in the organic ooze. Our studies show a great deal of novel diversity in these striking mats.

TO EAT OR NOT TO EAT: A THERMODYNAMIC MODEL OF FREE AND CALCITE-BOUND ORGANIC MATTER RESPIRATION BY KARST MICROBES

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In the subsurface, heterotrophic microbes require organic matter (most likely from the surface) both as a carbon source and as an electron acceptor to be used during respiration. While the utilization of free simple organic molecules is most likely energetically favorable, molecules that are sorbed to mineral surfaces must first be desorbed making their utilization less energetically favorable. The goal of this study was to calculate the energy yield of the utilization of simple, organic molecules of varying concentrations (free versus bound citric acid and benzoic acid) and then model the environmental conditions that constrain their use in karst vadose zone-like systems. We assemble organic compound/O₂/CO₂ stability fields that make it possible to predict the conditions under which substrates can or cannot be used. Our results suggest that under certain conditions likely to be found in the subsurface, the utilization of compounds such as benzoic acid that are more strongly bound to calcite is energetically unfavorable and, thus, cannot be utilized as a source of organic C to cave-dwelling microbes. These results have implications for

the possible role of microbes in calcite dissolution/precipitation in the subsurface.

LEG LOSS AS A MEASURE OF FITNESS IN CAVE CRICKETS (*HADENOECUS SUBTERRANEUS*) IN MAMMOTH CAVE NATIONAL PARK, KENTUCKY
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Hadenoeus subterraneus is a keystone species in central Kentucky caves, leaving the cave to forage on nights when conditions of temperature and humidity are favorable, and returning to the cave for a daytime refuge. Invertebrates are preyed upon by a wide range of animals and have developed defenses, including autotomy, or voluntary loss of a limb. Our study was done to determine if missing limbs affected the fitness of cave crickets. We used a visual census to record frequency of missing legs by gender among adult cave crickets at eight different cave locations in Mammoth Cave National Park. We expected males to be missing legs more frequently than females because they must leave the refuge of the cave to forage more frequently than females, but males and females were missing legs in equal frequency. The hind leg is missing significantly more commonly than other limbs (78% Hind vs. 7% Middle vs. 13% Front), probably because crickets attempt to jump away from threats, making the larger hind limb closest to the predator. The frequency of crickets with missing limbs varied by location from a low of 6.2% of the sampled population, to a high of 28%. Two crickets out of 1077 were missing more than one limb. In general, crickets from caves that have higher levels of reproduction (source populations) had the lowest frequency of missing limbs, while crickets from populations that are not replacing themselves (sink populations) had the highest frequency of leg loss. Our results suggest that loss of limbs reduces fitness in cave crickets.

CAVE/KARST CONSERVATION, MANAGEMENT, AND RESTORATION

NSS KARST PARTNERSHIP FORUM: COLLABORATIONS FOR KARST PROTECTION

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What happens in local communities when land development encounters karst? Proactive communities find strategies to resolve karst issues as development occurs. In 2006, the NSS Conservation Committee initiated an outreach effort to educate land use planners, local planning officials, and developers about the importance of cave and karst conservation in the scope of local ecological systems. The NSS Karst Partnership Forum is achieving the goals outlined in its 2006 strategic plan. Forum members attended the American Planning Association National Conference in Las Vegas, April 2008. Forum Partners collaborated in creating a museum quality karst-outreach exhibit booth targeting solutions for planners and developers. The NSS Karst Partnership Forum also sponsored an accredited session on Development Solutions in Karst Regions. Forum Partners that financially sponsored and participated in the successful week-long karst outreach event include: Conservation Division of the NSS, National Cave and Karst Research Institute, National Speleological Foundation, Texas Cave Conservancy, and Virginia Tech's "Growing Communities on Karst". Eight NSS members from around the nation networked directly with the national planning community. Planners seeking information and answers for karst regions facing development pressure joined the NSS Karst Partnership Forum. The Forum is compiling a list of target communities in karst regions; networking communities with cavers, grottos, and scientists; designing a series of development conferences for karst regions; recruiting developers to network and assist; and developing a Web presence through the Karst Information Portal to provide karst ordinances from around the

world. The NSS Karst Partnership Forum is positioned to promote cave and karst protection across the nation through collaborations with developers and community planners.

CONSERVATION EASEMENTS FOR KARST PROTECTION AND CAVE CONSERVATION IN VIRGINIA

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A conservation easement is a legal agreement negotiated between a landowner and a government agency, a land trust, or other qualified conservation organization for protecting conservation values including caves and other karst resources. Conservation easements limit rights to subdivide or develop a particular piece of land. Conservation easements are permanent and appurtenant; deeds of easement restrict both current and future landowners. Conservation easements can ensure environmental protection of a property beyond the tenure of one landowner. Virginia landowners who donate conservation easements may realize substantial economic benefit from transferable state tax credits. Prior to making any decision to donate a conservation easement, landowners should consult an attorney and/or accountant having expertise in conservation easements. Conservation easements ought to require landowners to adopt best management practices to protect conservation values. Deeds of easement may specify practices including fencing livestock from losing/sinking streams, sinkhole dump cleanouts, and establishing fenced vegetated buffers around streams, springs, sinkholes, and caves. Virginia Outdoors Foundation (VOF) holds most of the 588,549 acres of conservation easements in Virginia. Approximately 2.6% of Virginia caves are located on properties protected by conservation easements held by VOF or The Nature Conservancy. The Virginia Department of Conservation and Recreation (DCR) Natural Heritage Program reviews proposed VOF conservation easements for biological significance and for presence of caves and other karst resources. The DCR Natural Heritage Karst Program assesses resources and makes recommendations to VOF, to other land trusts, and to individuals on ways to better protect groundwater and manage cave and karst resources.

SURVEYING THE HISTORIC SIGNATURES OF CARLSBAD CAVERNS NATIONAL PARK

Lois Man and Dale Pate

Carlsbad Caverns National Park

Since the initial discovery and exploration of Carlsbad Caverns in the late 1800s, visitors to the cave have documented their passing by leaving signatures and other inscriptions. Some of these signatures were left by important early explorers like Jim White and Ray V. Davis; others belonged to the guano miners. Many more, however, belonged to local residents and visitors from far away. The dates included with many of these signatures give important clues to the progress of early visitation and the areas most frequently visited. The National Park Service began an inventory of these signatures in 1983, but the process of recording them was not refined at the time and the project did not continue, other than occasional notations made by survey teams mapping in the cave. Beginning in 2007, the park resumed collecting historic signature data in a much more systematic way. This presentation will show historic photographs from the early days of Carlsbad Caverns exploration, and will describe the methods being used by teams collecting data about the signatures. The historic signature survey is intended to help preserve and record yet another aspect of the fascinating history of Carlsbad Caverns National Park.

THE VIRGINIA DCR KARST PROGRAM OVERVIEW

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Established in 1994 by the Virginia Department of Conservation and Recreation Division of Natural Heritage, the Karst Program works to protect biological and hydrological resources of Virginia's karst areas. Most program funding comes from EPA Section 319 Clean Water Act grants. Recently, a growing percentage of funding has come from other sources: Natural Heritage Program funds, grants from NGOs such as the Cave Conservancy of the Virginias and the Nature Conservancy, and contracts with government agencies and private companies. The karst program utilizes a three pronged approach - education and outreach, technical assistance, and data development. Education and outreach efforts target agency staff and local government officials through professional development workshops. Each year, dozens of educators attend workshops and facilitator trainings and learn to use the Project Underground Curriculum to teach about karst. Karst education staff fills leadership roles in the state-wide environmental education community, ensuring that karst issues are a priority. The karst program provides on-call expertise to localities, agencies, and citizen stakeholders. Every year, staff screens hundreds of projects, ranging from highway construction to conservation easements, for potential impacts to karst, and provides guidance on avoidance or minimization of impacts and conservation of karst resources. Staff assists Natural Heritage Program stewards in management and monitoring of the caves and karst of the Virginia Natural Area Preserve System. Data development efforts focus on karst resource inventories, hydrological studies, and biological and water quality monitoring. Many data development activities are initiated through technical assistance to fill in data gaps.

GEOLOGY AND GEOGRAPHY SESSION

STRUCTURAL AND FACIES CONTROL OF HYPOGENIC KARST DEVELOPMENT IN THE GUADALUPE MOUNTAINS, NEW MEXICO

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Cave development in the Guadalupe Mountains was controlled by fracture zones, faults, and structures associated with Permian and Tertiary tectonics. Local passage character can be affected by changes in facies and lithology. The overall pattern of cave development shows strong linear trends that are correlative to linear features seen in aerial photographs and geologic maps. These features are consistent with broader structural trends in the Guadalupe Mountains and reflect fracturing, faulting, and folding during uplift. Some anticlinal features reflect deposition of Permian sediments across syndepositional faults. Many of these syndepositional faults can be observed in the caves and exhibit a strong influence on both overall passage trends and on passage character. There are large breccia zones associated with syndepositional faults. In these areas, cave passages typically change from large, linear trunk passages to complex three-dimensional mazes of smaller passages. Forereef deposits, paleokarst, and paleochannels through the reef can also be preserved as breccia zones and have a similar effect on passage character. While overall speleogenesis crossed formational boundaries, lithology had some influence on passage character. The backreef units contain more rectilinear maze-type passages than the underlying reef and forereef units, probably reflecting more tightly-spaced fracturing and greater porosity. Large trunk passage development is prevalent in the Capitan formation, especially along the reef/forereef transition. Other facies changes exhibit significant, but more localized controls on passage character. Variations in reef facies, cementation, and dolomitization may also exhibit some localized influence on passage character.

CRYSTAL NUCLEATION, CRYSTAL GROWTH, AND THE CONCEPT OF SPELEOTHEM ONTOGENY

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Speleothem ontogeny has been introduced as a concept for using the form and interrelationships of mineral grains in speleothems as a means of deducing growth environment. To this end, there is a large body of existing literature on the growth of crystals that can be applied to the speleothem problem. Calcite, the most common mineral in speleothems, is peculiar in that the activation energy for two dimensional nucleation and thus growth of large single crystals is almost the same as the activation energy for three-dimensional nucleation and thus the growth of polycrystals. Calcite is thus highly sensitive to minor impurities that may poison growth in certain crystallographic directions or may poison growth altogether. Growth may also be modified by epitaxy on templates, of which humic substances are a possibility. Observations with the atomic force microscope have revealed the atomic scale mechanisms of calcite growth and thus provide an explanation for the growth behavior observed at the macro-scale. Aragonite is much less sensitive to impurities than calcite and grows easily at high supersaturation. However, growth is rapid in preferred crystallographic directions, resulting in both fiber and dendrite growth. Gypsum, also, has preferred fast growth directions resulting in fibrous growth habits. The smallest fibers (angel hair) appear to be the result of whisker growth along a single screw dislocation. Gypsum needles grow as re-entrant twins, a mechanism widely studied by the semiconductor industry as the growth mode of silicon ribbons. Much of the information needed to understand speleothem ontogeny already exists.

INTERREGIONAL COMPARISON OF KARST DISTURBANCE: WEST-CENTRAL FLORIDA AND SOUTHEAST ITALY

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The karst disturbance index (KDI) consists of 30 environmental indicators contained within the five broad categories: geomorphology, hydrology, atmosphere, biota, and cultural. The purpose of this research is to apply the KDI to two distinct karst areas, West Florida, and Apulia, Italy. Through its application, the utility of the index can be validated and other important comparisons can be made, such as differences in the karst legislation implemented in each region and effect of time exposure to human occupation in each karst terrain. Humans have impacted the karst of southeast Italy for thousands of years compared to decades in west-central Florida. However, west-central Florida is more populated than southeast Italy establishing differences in the scale of human occupation between the two studied areas. These two differences allowed for the determination of whether length of human occupation or population density is most influential in the anthropogenic destruction of karst terrains. Similarly, Italian karst is more diverse than the karst found in west-central Florida, aiding in the evaluation of the applicability of each KDI indicator through the application of the index in distinctly different karst terrains. Overall, major impacts for southeast Italy include quarrying, stone clearing, and the dumping of refuse into caves, while west-central Florida karst suffers most from the infilling of sinkholes, soil compaction, changes in the water table, and vegetation removal.

COASTAL CAVES IN BAHAMIAN EOLIANITES: ORIGIN AS FLANK MARGIN CAVES, SEA CAVES, AND TAFONI CAVES

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Bahamian Quaternary eolianites in coastal settings contain breached flank margin caves, sea caves and tafoni caves. Flank margin caves are dissolutional features formed by water mixing internally within the subsurface, as sealed chambers, whereas sea caves and tafoni caves form by nondissolutional processes acting from the outside inward. These three cave types, while similar in outcrop appearance, can be differentiated by application of two measures: area to perimeter ratio, and maximum cave-width to entrance-width ratio. Flank margin caves and sea caves are tied

to sea-level position, and are good paleo sea-level indicators, whereas tafoni caves form at random elevations on exposed cliffs. Based on their size, shape and configuration, flank margin caves carry information on paleo fresh-water lens conditions. Sea caves have been classified in the literature based on the nature of lithological or structural differences (e.g. faults and intrusions), but sea cave distributions in the relatively uniform Quaternary eolianites of the Bahamas implicate off-shore focusing of wave energy as an additional factor. Subaerial erosion progressively removes sea caves, then breaches flank margin caves, allowing denudation rates to be determined. Tafoni caves form wherever Quaternary eolianites are cliffed to present an unweathered surface lacking a calcrete crust. Tafoni development in eolianites is caused by wetting/drying cycles and wind, as no halite or gypsum were found within tafoni. Tafoni develop quickly, growing to meters in size in Holocene dunes and tens of centimeters in size in road cuts, buildings and quarries.

ENVIRONMENTAL RAMIFICATIONS OF NOT RECOGNIZING THE SUBJACENT KARST COLLAPSE SINKHOLES DEVELOPED ON THE EDGES OF THE CUMBERLAND PLATEAU ESCARPMENT IN TENNESSEE

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A narrow, flat area called the Hartselle Bench exists approximately half way up the steep Cumberland Escarpment in Tennessee. It is underlain by the resistant, Mississippian-aged Hartselle Sandstone. Most of the state's deep pits occur in the underlying Monteagle Limestone due to cave roof collapse up into the Hartselle. The Hartselle varies in thickness from 20 to 60 feet, but erosion has caused many areas of the Hartselle Bench to have less than 20 feet of sandstone. In many areas, broad, shallow sinkholes occur, that are not recognizable from the 20 foot topographic contours. As a result, state regulators can make bad decisions permitting waste disposal sites not understanding subjacent karst phenomena. In one incident, the author became involved at a site where chicken processing grease was being disposed of in a broad, shallow sinkhole on the Hartselle Sandstone. The grease was emerging from a nearby, underlying Monteagle cave spring with a grease-laden cave trending toward the sinkhole. The site had been permitted based on its porous sandstone soils and underlying bedrock type. Topographic maps did not depict the sinkhole. Housing developments are increasingly occurring on the Hartselle Bench due to the scenic views of the Highland Rim plateau surface below and ease of obtaining a septic tank permit on the sandy soils. There is a need to educate the regulatory community about the pollution potential of waste disposal on thin areas of Hartselle sandstone and develop regulatory statutes to require a special "karst investigation" before permitting sites.

INFLUXES OF MATRIX PERMEABILITY ON CONDUIT FLOW IN EOGENETIC KARST

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In the eogenetic Upper Floridan Aquifer (UFA), high intergranular porosity (20–40%) and matrix permeability (10^{-12} – 10^{-14} m²) may contribute to the aquifer's hydraulic diffusivity (transmissivity/storativity), flow paths, and mass transport. To assess the exchange of water between intergranular and conduit porosity in the UFA, we conducted two quantitative dye traces during high and low flow conditions in the lower portion of the Santa Fe River Sink-Rise system in north-central Florida. For each tracer test we injected 18.14 kg (40 lbs) of 20% Rhodamine WT solution (3.63 kg active ingredient) into a karst window called Sweetwater Lake, which connects to a first magnitude spring, the River Rise, via a single conduit previously mapped by cave divers. Fluorescence of river water and river stage were monitored continuously until fluorescence returned to background values. In addition to river water, ground water was monitored from wells located 30 to ~890 m from the conduit. The high flow test had breakthrough of dye occurring 13 hours and 58 minutes

following dye injection, a peak concentration of 6.97 ppb, and average flow velocity of 0.038 m/s. The low flow test had breakthrough of dye occurring 54 hours and 34 minutes following dye injection, a peak concentration of 4.87 ppb, and average flow velocity of 0.0077 m/s. High fluorescence was detected in three wells during the high flow test, suggesting conduit water may have been lost to the matrix, but no fluorescence was detected in the wells during the low flow test.

INFLUENCE OF THE HYDROGEOLOGICAL SETTING ON ENGLACIAL CONDUIT MORPHOLOGY

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Glaciological ideas about the character and evolution of englacial drainage systems (glacier "caves") have been deeply influenced by the theoretical model developed by Shreve (1972). This model is based on three main assumptions: (1) englacial drainage is in steady state; (2) englacial water will flow along the steepest hydraulic gradient within the glacier; and (3) pressure head equals the pressure of the surrounding ice minus a small component due to melting of the walls. The Shreve model has been widely adopted as a fundamental component of englacial drainage theory. There is no evidence, however, that the model provides a realistic picture of actual glacier drainage systems. Observed englacial drainages show no discernable tendency to follow theoretical potential gradients and generally do not behave as predicted by the model. Conduit surveys from nine expeditions between 2005 and 2008 to glaciers that bracket the full range of common glacier thermal and structural regimes indicate that conduits do not form as predicted by the Shreve model. Englacial conduit morphologies are intimately linked to the orientation of a glacier's principle stresses or the presence of pre-existing lines of high hydraulic conductivity. If a sufficient supply of water is available, hydrofracturing forms vertical conduits in zones of longitudinal extension and subhorizontal conduits where longitudinal stresses are compressive. On unfractured glacier surfaces, subhorizontal conduits with migrating nickpoints form by cut-and-closure provided channel incision is significantly faster than surface lowering. Conduits can also form along permeable debris-filled crevasse traces that connect supraglacial lake basins of different potential.

FLANK MARGIN CAVE DEVELOPMENT IN EOLIANITES: THE INFLUENCE OF TERRA ROSSA PALEOSOLS

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Eolian calcarenites, in island settings (Bahamas) and continental settings (southern Australia), contain flank margin caves. These eolianite sequences consist of dunes deposited during sea-level highstands separated by terra rossa paleosols developed during sea-level lowstands. The role of these paleosols in cave development has been confusing. As surface outcrops, the paleosols form a catchment that can collect meteoric water and deliver it to pit caves. In the subsurface, the paleosols have been ignored in some localities, with cave passages developing through the paleosol as if it were ordinary limestone. In other localities, the paleosol has acted as an aquiclude, distorting the shape of the fresh-water lens with a consequent impact on the nature of the cave passages below. One such distortion is a pinching out of flank margin caves both above and below a given paleosol. Another distortion is the ramping of the lens upwards along a paleosol inclined as it follows the side of an older dune ridge, creating passages at elevations higher than expected, as well as passages with a significant linear extent, as at Hatchet Bay Cave, Eleuthera. At scattered locations in the Bahamas, caves that look like flank margin caves are found at elevations above any known past sea-level highstand, from

20 m at Osprey Cave on Crooked Island, up to 55 m at St Francis Grotto (Big Cave) on Cat Island. These caves may be perched on a paleosol, and so reflect development more as a banana hole cave than as a flank margin cave.

SPELEOTHEM PALEOCLIMATOLOGY OF THE LAST DEGLACIATION FOR TWO CAVES IN YUCATAN, MEXICO

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Speleothems were sampled from Cueva Columnas and Cueva Oxpehol in Yucatan, Mexico. Samples from Columnas and Oxpehol have basal ages placing the initial growth of the stalagmites in the last glacial period (U/Th basal ages range from 21,089 to 30,816 years). Oxygen and carbon isotopes were measured on calcite samples drilled every 0.5 mm along the growth axis of these speleothems. Oxygen and carbon isotope values from stalagmites decrease along the speleothem growth axis. These results are consistent with recent findings in sediment cores from Lake Peten Itza in Guatemala and expected changes in oxygen and carbon isotope values across the Pleistocene/Holocene (P/H) boundary. Previous pollen studies on lake cores indicated a cooling of 6 to 8 °C during the Pleistocene in the Maya lowlands, which would have increased the $\delta^{18}\text{O}$ of speleothem calcite. Furthermore, the Maya lowlands were drier during the Pleistocene, which should also have been expressed by an increase in the $\delta^{18}\text{O}$ of speleothem calcite owing to an increase in the $\delta^{18}\text{O}$ of rainfall (i.e., the amount effect). During the glacial period, the abundance of dry-adapted C_4 vegetation was greater than today and transitioned to an increased abundance of C_3 vegetation at the start of the moister Holocene. The decrease in the carbon isotopic values across the P/H boundary is consistent with such a vegetation shift above the cave. Other current work includes a detailed investigation correlating rainwater and cave drip water $\delta^{18}\text{O}$ ratios to precipitation amount in the Yucatan Peninsula.

A COMPARISON BETWEEN GLACIAL AND MID-HOLOCENE CLIMATE IN FLORIDA USING SPELEOTHEM STABLE ISOTOPES: EVIDENCE OF HEINRICH EVENT 2

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A stalagmite collected from BRC Cave in west-central Florida was deposited from 29 ky to 21 ky BP, encompassing Heinrich Event 2 (H2), and from 5 ky to 4 ky BP, during the mid-Holocene. The timing of H2 in our record is ~24 ky BP, which is temporally similar to its timing in other areas worldwide. However, the oxygen and carbon isotope values indicate the climate in Florida was warm and wet, rather than cool and dry like many other regions, with more precipitation and a shift from savannah to forest during this period. One possible cause is shutdown of the North Atlantic Conveyor Belt due to increased glacial meltwater input, thereby preventing heat transfer by the Gulf Stream from the subtropics/tropics to the northerly latitudes. This mechanism would allow for an increase in convective thunderstorm activity due to higher evaporation rates. In contrast to the H2 event, the mid-Holocene speleothem oxygen isotopes show a ~2‰ shift, indicating higher precipitation amounts than the glacial period. Additionally, the carbon isotopes show a ~3‰ shift towards more negative values, indicating more heavily forested conditions during that time. The speleothem isotopes during the mid-Holocene reflect a warmer and wetter environment than the end of the glacial period. The preliminary data support the possibility of atmospheric teleconnections between the tropics/subtropics and northerly latitudes playing a major role in controlling climate change in Florida. Possible causes include changes in the migration pattern of the Intertropical Convergence Zone and the influence of El Niño on Florida's winter precipitation.

CHARACTERIZATION OF AIRFLOW USING SIMPLE TEMPERATURE-HUMIDITY LOGGERS, CARLSBAD CAVERNS NATIONAL PARK, NEW MEXICO

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The characterization of airflow from caves and blowholes is important for broad resource understanding, determining cave potential, and evaluating the effects of gating or other passage modifications. The hypogenic caves of the Guadalupe Mountains are vertically complex and some have tremendous volumes. These caves can exhibit barometric or chimney-effect airflow or combinations of the two. Detailed, extensive airflow studies can be labor and cost prohibitive. The park has experimented with using simple temperature-humidity loggers located inside cave entrances to provide general characterization of airflow. Loggers were placed inside cave entrances out of the direct influence of minor changes in surface weather. A baseline pressure logger was kept in the park headquarters area to monitor changes more closely than available at the nearest weather station. Readings of temperature, humidity, and pressure were logged every two hours. The data from Lechuguilla Cave and a smaller, partially-explored backcountry cave show that these loggers can detect changes in airflow caused by both major and minor changes in surface conditions. As shown in previous studies, the data show that airflow in Lechuguilla Cave is primarily controlled by changes in barometric pressure. The data from the backcountry cave shows that the airflow is primarily due to chimney effects, controlled by fluctuations in surface temperature, especially seasonal changes in average daily temperature. The results of this preliminary study show that simple temperature-humidity loggers can be used to characterize the controls on airflow. This type of characterization can be done inexpensively with minimal labor and equipment.

THERMAL IMAGING AND TEMPERATURE ANALYSIS OF PARKS RANCH CAVE, NEW MEXICO

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The main entrance to Parks Ranch Cave, NM was imaged over a 24 hour period using a long wave infrared camera. Temperature, humidity and barometric pressure measurements were taken inside and the cave and out during the same period. Wall temperature measurements were taken at the entrance of the cave and tens of meters inside. During the January, 2008 measuring period, the cave entrance had a pronounced outflow of warm, moist air in the upper half of the passage. The lower half had cold, dry air flowing in. This pattern probably continues for a significant period of time, as evidenced by a layer of dark green algae coating the passage wall that is in full (but indirect) daylight, coinciding with the level of out-flowing humid cave air. The out-flowing air moves at less than 0.5 m/s, however the effect of the airflow extends well beyond the dripline. When the air temperature falls below freezing, frost accumulates on the headwall several meters above the entrance as the humid cave air drops below the dewpoint. Parks Ranch has 18 known entrances to the system. A second entrance lies immediately below the main one, but does not show same strong, differential airflow. Much work remains to be done to understand the airflow in this complex cave system.

METRICS OF CAVE COMPLEXITY WITH APPLICATION TO MAPPED TENNESSEE CAVES

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Mazes in caves may occur due to frequent loop connections in a single level, to overlay of multiple levels, to vertical solution in domepit complexes, or to combinations of factors. Cave mazes pose difficulties for the explorer, representational dilemmas for the cartographer, and, at times, interpretational challenges for the karst researcher. The common

generalization of cave patterns as single conduit, branchwork, network, etc. are useful as general descriptive terms, but fail to allow numeric specification of the degree of mazelike character or to permit comparisons of distinct maze sections within a single cave. This paper introduces passage spacing and complexity metrics based on equivalent values to those of similar-dimensioned hypothetical square maze caves with square loop components. A cave intricacy descriptor, invariant under scale changes, is also posed. These metrics are illustrated using a selection of mapped Tennessee caves of varying lengths and degrees of mazelike character. Adaptations of these metrics to examination of complexity variations within more complex caves are presented with a few examples. Tennessee has more than 9000 caves recorded by the Tennessee Cave Survey (TCS), of which approximately 1500 have been mapped. Mapped caves span nine physiographic provinces (as defined by the TCS) in limestones ranging from Cambrian to Mississippian in age. Relationships of cave complexity to physical variables such as geologic formation and physiographic province are tentatively explored for the non-random subset of approximately 500 caves for which complexity data have been compiled, with emphasis on caves over one kilometer in length.

INTERNATIONAL EXPLORATION

FIRST U.S. AND NSS CAVING EXPEDITION TO ARMENIA, THE SOUTH CAUCASUS

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The first U.S./NSS caving expedition to Armenia took place August 2007, with a team of 5 California cavers. Four significant caves within the Vayots Dzor province were explored. Mozrovi Cave: A cave (1,554 m. elevation) with 700 meters of passage. Notable for its large main chamber, its wonderful multicolored speleothems - stalactites, stalagmites, flowstone, draperies, helictites, crystalline spars, bacon, and moon milk - and passages containing pristine coral formations. Arjeri Cave: The largest of Armenia's caves (1,676 m elevation) with approximately 4 kilometers of passage - a world-class cave. The team encountered colorful speleothems - stalactites, stalagmites, flowstone, columns (large and small), draperies, bacon, coral, moon milk. The quantity (and size) of such calcite formations throughout this relatively pristine cave were remarkable. A bat colony resides in the cave. Karmir Cave: This is the smallest of the caves (2,134 m elevation) with red cave mineralization throughout much of the passages. Mageli Cave: The cave (1,219 m elevation) has approximately 2 km of known passage, and is in conglomerate, as opposed to classical karst, with high, narrow booming passages, crawls, climbs, and squeezes. The amazing 3.7 meter long, slotted venturi squeeze with high velocity wind is noteworthy. The cave is also home to a large bat colony. The team also visited the magnificent cave monastery of Geghard, and the cave church of Jerovank. Natural or man-made, caves have played a significant role in the history of Armenia and the Armenians.

THE QUINTANA ROO SPELEOLOGICAL SURVEY: RECENT EXPLORATIONS IN DRY AND UNDERWATER CAVES IN QUINTANA ROO, MEXICO

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The Quintana Roo Speleological Survey supports conservation, safe exploration and confirmed survey documentation of the caves in Quintana Roo, Mexico. The present study area incorporates 8500 square kilometers (km) in eastern Quintana Roo. Over 44 km of cave survey is reported for the preceding year. Our area of interest contains 169 independent underwater caves (729 km of surveyed passage), and 22 independent dry caves (12.3 km of surveyed passage). Over 200 collaborators have contributed raw survey data to the database, establishing one of the largest archives of underwater survey data in the world. Current investigations of underwater caves south of the town of Tulum continue to support an aerial geomagnetic survey of the fresh water aquifer. Explorations in Sistemas Alomo, Toh Ha, and Dos Pisos reinforce a

southern origin for the local aquifer. Explorations north of Tulum in Sistema Actun Hu and caves inland from the town of Chemuyil support this component for the aquifer. Dry cave exploration under a Pleistocene ridge common to the area is producing exciting results. Sistema Tixik K'una is progressing south along a large fracture towards another dry cave. In the northern area, a connection between Tixik K'una and two terminal sumps in Sistema Xunaan Ha (a sizeable underwater cave) is imminent. Exploration in both areas of the dry cave continues.

CAVES AND NON-CAVES OF FAIS ISLAND, FEDERATED STATES OF MICRONESIA

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Fais Island, Yap State, Federated States of Micronesia, is an uplifted carbonate atoll 1.2 km wide and 2.9 km long with a maximum elevation of 28 m, located 220 km east of the island of Yap in the Western Pacific. Field reconnaissance for water resources in 2005 located a variety of features that had been identified as karst features by earlier workers. However, the feature called a "cenote" was actually a well dug into sand and partially lined with fitted stone, and the "unroofed stream caves" were actually spur and groove depositional reef structures, fossilized by tectonic uplift into the subaerial environment. The only true dissolutional caves were a number of flank margin caves found only on headlands around the perimeter of the island. These headlands were preferential flow paths for the fresh-water lens, and thus controlled cave development. The flank margin caves were all of small to modest size, with only one, Ngatarocoroc Cave, having a true dark zone. But the caves are located in spectacular settings, and some can only be reached at low tide during calm conditions. Cave interiors show many fossils in the wall rock, and some caves, as at Yicimal Point, show evidence of fossil marine infill. The caves did not show evidence of cultural or religious use, but Ngatatapurowag Cave was used by Japanese soldiers as a hideout at the end of World War II, until they were killed by U.S. soldiers sent to clear the island in September, 1945.

SOPLO DE LOS TOROS UPDATE, CAVING IN THE PURIFICACIÓN KARST

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In December 2007, work continued in Soplo de Los Toros, a recently discovered deep cave in the Purificación karst of northern Mexico. On two prior expeditions we had explored the cave to 366 meters deep with excellent prospects for continuing. This time the nature of the cave changed dramatically, becoming tight and sinuous. Three trips to the bottom managed to add only 94 meters of depth, pushing the cave to 459 meters deep. The narrow canyon continues, and will be pursued later this year. Meanwhile digging in a neighboring cave, Poza de Zorillo, opened up a series of short drops with airflow. That cave was pushed to 83 meters deep before time ran out at another drop, and may connect to Soplo next trip. With any luck Soplo will become the second-deepest cave in the Purificación area and deepest in the state of Nuevo León when we return in December 2008.

CAVE RECONNAISSANCE, CROOKED AND ACKLINS ISLANDS, BAHAMAS

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A seven-day reconnaissance trip to Crooked and Acklins Islands, Bahamas in December of 2007 built on a very short three-day visit to Crooked Island in May of 2004. The 2004 trip mapped one large and two small flank margin caves at the northwest end of Crooked Island. The 2007 trip mapped 20 caves across Crooked Island, most of small size, but some had spectacular features or were located in dramatic settings. Other caves were short, grungy holes deep in the bush. Many of the flank margin

caves had unusually large and high bell holes; in some caves surface denudation had breached these bell holes to create cave ceilings with numerous perforations. One of the flank margin caves was unique as it was developed in and through a limestone blockfall and talus deposit. On Acklins Island, a single large-chamber flank margin cave was mapped during a one-day visit by ferry to assess the island's cave potential. Several large caves were reported by locals, indicating a cave-mapping trip focused on Acklins Island would yield results. The majority of caves surveyed in 2007 were flank margin caves (19), but one sea cave and one tafoni cave were mapped. The total mapped caves on both islands from both trips is 24, with 22 being flank margin caves. The last day of the trip, as always seems to be the case, we were informed of another large cave on Crooked Island in an area we had been close to, justifying a return.

INSIDE THE LAVA DOME – EXPEDITION TO LANZAROTE

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Just 97 kilometers from the North African coastline, the peaceful island of Lanzarote hides its volatile past. Along this island arc are dynamic features that have revealed the earth's innermost geologic secrets for perhaps millions of years. Sudden, violent eruptions have formed virgin islands overnight. To modern cave divers, Lanzarote has more than just a fiery history. Over a quarter century ago, this, the longest submerged lava tube in the world, almost claimed the life of cave diving pioneer Sheck Exley. From its vast size, unparalleled grandeur and enduring mysteries, it is easy to see why the final submarine section of the lava tube became known as the tunnel to Atlantis. Several collapses on the lower slopes of the Monte Corona volcano provide entrances to the cave system. The tunnel is over 6 km long with an additional 1.6 km under the sea and about 2 km open to the public. We accessed many wild portions of the cave with basic dry caving and sump diving techniques. Diving in Atlantida Tunnel is only possible through rare scientific permits, but it is not because of the challenges of entry. In fact, after walking through a show cave complete with a swimming pool, restaurants and concert hall, we arrived at our dive site. Carrying our gear, we paraded past tourists standing at the bar, and weaved between diners and sightseers and climbed over a railing in the restaurant to get to the water. In 2008, Dr. Tom Iliffe, Terrence Tysall, Jim Rozzi and Jill Heinerth explored the cave using closed-circuit rebreathers to add greater margins of safety while minimizing our effect on the environment that unique stygobitic cave animals depend on.

RECONNAISSANCE OF SOUTHWEST COAST OF HAITI

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In 2007, in response to an invitation from tourism developers in Haiti, a small team of cavers began an initial cave and karst reconnaissance of the southern central part of the country. A number of karst features were documented and exploration/survey began in two caves located on a small limestone plateau in the Massif de la Hotte area. The larger of the two is Grotte Marie-Jeanne and consists of a series of sizeable, well-decorated chambers developed on multiple levels which gives the cave an unusual morphology. The cave contains many entrances and skylights which show evidence of unique cave ecosystem which has not yet been fully identified or studied. The other cave in the area shows evidence of pre-historical and historical human usage of the cave and surrounding landscapes making it an important part of the cultural and ethnic history of the area and of the island. One significant karst spring was documented though its relationship to the other known caves in the area is not yet known.

EXPLORATION OF CAGUANES NATIONAL PARK, CUBA

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In November 2007, a team of US cavers with a team from the Comité Espeleológico de Sancti Spiritus, Sociedad Espeleológica de Cuba traveled to Caguanes National Park on the north coast of Cuba. Many of the caves in the area had been mined for guano up to the 1950s and most had been documented by the famous Cuban naturalist Antonio Nuñez Jiménez fifty years ago. The goal of this expedition was to survey all of the known caves and tie them together using surface surveys and limited global positioning data into a GIS project. Correctly determining the spatial relationships and morphology of the caves was used to determine their speleogenesis and identify additional cave potential. More than 11 kilometers of passages were mapped in seven main caves. Some smaller, coastal caves were also located and mapped. The caves appear to be primarily flank-margin-type caves though the timing and specific hydrologic mechanism of speleogenesis is unclear. The caves are large and well-decorated and are host to several colonies of bats, including the rare butterfly bat. Several interesting microbial colonies were observed and documented and some very well-preserved vertebrate paleontological remains were found.

WULONG, CHINA 2008

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In 2008, a series of international expeditions by the Hong Meigui Cave Exploration Society explored the karst and caves of northern Wulong County in Chongqing, China. The teams surveyed over 20 kilometers and identified numerous new karst features, caves, and springs in the Tongzi, Huolu, and Houping areas. Highlights include Gan Dong (Dry Cave), a 2,213 m-long stream cave, and Shang Hetaowan Dong (Upper Walnut Bend Cave) which was extended to 8,489 m long and 471 m deep with only one short pitch, making it the 6th deepest in China. Over 2 km were mapped in Quankou Dong (Spring Mouth Cave), extending it to 3,561 m long and 114 m deep, including sections of impressive air flow. Exploration also continued in the core zone of the Wulong Karst World Natural Heritage site, where San Wang Dong was extended to 34,767 m long, 293 m deep and Er Wang Dong to 26,021 m long, 241 m deep.

FOUR YEARS UNDER THE ICE: GLACIER CAVING ON MT. EVEREST, IN THE HIGH ARTIC, AND IN ALASKA 2005–2008

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Increasing temperatures in glaciated areas are increasing melt rates and most glaciers are now losing mass and/or retreating. On the Greenland Ice Sheet (GrIS), increased melting has accelerated outlet glacier velocities, indicating englacial conduits (glacier caves) are funneling meltwater to the bed and “lubricating” glacier motion. To understand how and where conduits might form on GrIS, we are studying glacier caves on more accessible high arctic glaciers in Svalbard, Norway (78°N), that are analogues to GrIS outlet glaciers. We have fielded three glacier caving expeditions and explored more than 10 km of englacial conduits – including Christel Høhle, which, at 2 km long, replaces Patagonia's 1,040 m-long Perito Meccanico as the world's longest englacial conduit. Other notable finds include descending through 70 meters of ice to the bed of Hans Glacier in Crystal Cave. While warming on GrIS has resulted in faster ice, increasing temperatures in the Mt Everest region of Nepal are causing debris-covered glaciers to downwaste and stagnate. Lakes form in topographic hollows on stagnant glacier surfaces which can drain catastrophically and flood Sherpa villages down-valley. We launched two expeditions to map conduits associated with lake drainage events to understand how conduits affect lake life-cycles. Caves on or near Mt

Everest were mapped at altitudes between 4,900 m and 5,300 m, making them the highest surveyed caves in the world. This research has been combined with data collected from three expeditions to the Matanuska Glacier, AK, to inform a new conceptual model of glacier hydrology based on karst processes.

PALEONTOLOGY

UNIQUE OCCURRENCES OF FOSSIL MARINE INVERTEBRATES FROM CAVES DEVELOPED IN THE OCALA LIMESTONE OF NORTHERN FLORIDA

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Northern Florida caves developed in the late Eocene Ocala Limestone provide whole and partial (articulated and disarticulated) calcitic-shelled invertebrate fossil taxa thus far not found in quarries and river bottoms exposing that formation. Surface deposits typically fail to preserve well-exposed, well-preserved, multi-component invertebrate fossil skeletons because quarries and river bottoms typically undergo rapid change; either natural (e.g., erosion or sedimentation) or man-made (e.g., blasting). However, slowly eroding limestones in protected cave environments have a higher probability of recovery of these types of fossils. Recently, two caves yielded well-preserved calcitic-shelled invertebrates never before reported in scientific literature. These include new species of crabs (Families: Parthenopidae, Majidae and Mithracidae), shrimps (Families: Callianassidae and Ctenochelidae), and an echinoid (sea biscuit). Although some were collected from cave walls, most were derived from cave floor sediments removed in 1-liter plastic water bottles. Fossils were collected from coarse-grained sand and fine-grained clays from Jackson Blue Springs (high flow water-filled cave) in Jackson County and fine-grained clays from Catacombs Cave (water table cave) in Marion County. Great care was taken by experienced cavers to minimize impact on the cave's floor and walls. It is hoped that with additional searching by experienced cavers other undescribed fossils, or those currently known only from disarticulated parts (e.g., sea stars, brittle stars, and sea lilies), will be discovered, carefully removed, and brought to the attention of Florida Museum of Natural History invertebrate paleontologists. Discoveries such as these are critical to our understanding of Florida's paleobiodiversity and paleoecology 35–40 million years ago.

RESEARCH & EXPLORATION IN FLORIDA CAVES

CONTINUOUS MONITORING OF THE MICROMETEOROLOGY OF A NATURAL CAVE SYSTEM: HOLLOW RIDGE SPELEOCLIMATOLOGY

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We are monitoring cave air, drip water and climatology at Hollow Ridge Cave to calibrate isotopic and chemical paleo-proxies in speleothems. Two monitoring stations located 50 m and 200 m within the cave and one station above the cave continuously record temperature (T), relative humidity (RH), barometric pressure (BP), drip rates (precipitation), acoustic airflow (wind) velocity, ^{222}Rn activities and CO_2 concentrations. Correlation of $^{13}\text{CO}_2$ vs. $1/\text{CO}_2$ indicates that soil gas ($\delta^{13}\text{C} = -22$ per mil) is the dominant CO_2 source in the cave. Radon-222 (20–340 dpm/L) and CO_2 (400–1500 ppm) rise and fall coherently as the cave breathes daily. Each parameter shows temporal and spatial patterns that reflect different sources – emanation from bedrock vs. soil gas and dripwater infusion. Temperature and BP drive the air exchange between atmosphere and cave under normal conditions. An unexpected flooding event once sealed the cave entrances, allowing ^{222}Rn to grow into secular equilibrium. Radon-222 peaked at 1200 dpm/L, over three-fold higher than previously measured, while CO_2 peaked at 1400 ppm, similar to peak CO_2 under normal conditions. Several methods can estimate cave air

exchange rates including ^{222}Rn deficiency, CO_2 exhalation, temperature variations, and the $\delta^{13}\text{C}$ of carbon dioxide. A simple radon-deficiency model is used to estimate air exchange rates (fractional tidal air volumes) and CO_2 exhalation rates, varying from 18 to 26% of the cave volume.

A MULTI-PROXY APPROACH TO USING CAVE SEDIMENT CARBON ISOTOPES FOR LATE HOLOCENE PALEOENVIRONMENTAL RECONSTRUCTION IN FLORIDA

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Cave sediments collected from Jennings Cave in Marion County, Florida were analyzed using a multi-proxy approach. Fulvic acids (FAs), humic acids (HAs), bulk organic matter, and phytoliths were extracted from the sediments for carbon isotope analysis to determine periods of vegetation change caused by climatic influences during the Late Holocene (~ 3,000 years BP). Magnetic susceptibility and density analyses were also performed to compare physical sedimentary characteristics related to precipitation to the carbon isotopes. The carbon isotope record ranges from -35 to -14 per mil, exhibiting variability of ~21 per mil, within the different proxies, which indicates changes between C_3 and C_4 vegetation. Density analysis closely matches the FAs, indicating changes in the sediments during shifts in the vegetation regime. This likely indicates changes between a sub-tropical forested environment and more arid, grassy plains conditions. 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 C_3 vegetation (increased C_4 vegetation) during the Medieval Warm Period. The cave sediment fulvic acid carbon isotope record agrees well with $\delta^{13}\text{C}$ values from a speleothem collected nearby that covers the same time period. Prolonged migration of the North Atlantic Oscillation and Intertropical Convergence Zone affects precipitation in Florida and likely caused vegetation changes during these climatic shifts.

NUCLEAR MAGNETIC RESONANCE IMAGING OF DENSITY-DEPENDENT FLUID EXCHANGE BETWEEN MACROPOROSITY AND MATRIX IN AN EOGENETIC KARST AQUIFER

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Sequential time-step nuclear magnetic resonance images show the displacement of deuterated water (D_2O) by freshwater within two limestone samples characterized by a porous and permeable limestone matrix of peloids and ooids. These samples were selected because they have a macropore system representative of some parts of the eogenetic karst limestone of the Biscayne aquifer in southeastern Florida. The macroporosity, created by the trace fossil Ophiomorpha, is well connected and of centimeter scale. These macropores occur in broadly continuous stratiform zones that create preferential flow layers within the hydrogeologic units of the Biscayne aquifer. This arrangement of porosity is important because in coastal areas it could produce a preferential pathway for saltwater intrusion. Two experiments were conducted in which samples saturated with D_2O were placed in acrylic chambers filled with freshwater and examined with nuclear magnetic resonance imaging (NMRI). Results reveal a substantial flux of freshwater into the matrix porosity with a simultaneous loss of D_2O . Specifically, we measured rates upward of 0.001 milliliters per hour per gram of sample (mL/hr-g) in static or non-flowing conditions, and perhaps as great as 0.07 mL/hr-g when freshwater continuously flows past a sample at velocities less than those found within stressed areas of the Biscayne aquifer. These experiments illustrate how freshwater and D_2O , with different chemical properties, migrate within one type of matrix porosity found in the Biscayne aquifer. Furthermore, these experiments are a comparative exercise in the displacement of seawater by freshwater in the matrix of a coastal karst aquifer, since D_2O has a greater density than freshwater.

BIOTA INVENTORY OF PEACOCK SPRINGS AND BLUE HOLE AT ICHUTUCKNEE SPRINGS, FLORIDA

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The goal of the project is to establish baseline troglobitic population densities, and track long-term changes in the submerged cave systems of Peacock Springs, and Blue Hole at Ichutucknee Springs, by performing *in-situ* biota inventories. Biota inventories are performed on a quarterly basis, or when a significant change has occurred in the system such as a flooding event. A team of cave divers will inventory, cave crayfish (*Procambarus pallidus*), Florida cave amphipod (*Crangonyx grandimanus*), Hobbs cave amphipod (*Crangonyx hobbs*), swimming little Florida cave isopod (*Remassellus parus*), catfish, and sunfish, in specified distance intervals. This project was initiated in 2004, and data collection is still an ongoing process, but a couple of hypotheses have been generated. There is frequently an inverse relationship between concentration of catfish and other troglobitic species within a given distance, and following a flooding event it will take troglobitic species 5–6 months to rebound to preflooding levels.

A FLORIDA SPELEOTHEM RECORD OF VARIABLE INTENSITY OF TELECONNECTIONS DURING THE LATE HOLOCENE IN SUBTROPICAL NORTH AMERICA

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A stalagmite from west-central Florida was analyzed for its stable and radiogenic isotopes to determine the paleoclimate for the region over the last 1000 years. An investigation into how key ocean-atmospheric circulation patterns affect the region's climate was an important component of this study. The persistence and influence of both tropical and extra-tropical teleconnections on the hydrology of subtropical North America are little understood. We were able to reconstruct the major atmospheric-oceanic controls on the isotopic composition of the precipitation as recorded by the speleothem, controls that included the North Atlantic Oscillation (NAO) and the Pacific Decadal Oscillation (PDO). These teleconnections create decadal- to centennial-scale changes in the seasonal distribution of precipitation. An increase in the winter proportion of annual precipitation coincides with negative-phase NAO conditions and a positive-phase PDO. However, the PDO's influence appears to be weakened when it is out of phase with the El Niño Southern Oscillation (ENSO). The NAO exerts the greater decadal influence on this region's climate than the El Niño Southern Oscillation (ENSO), suggesting a greater significance of high latitude controls on subtropical North America.

A GIS-BASED INVENTORY OF TERRESTRIAL CAVES IN WEST-CENTRAL FLORIDA: IMPLICATIONS FOR SENSITIVITY, DISTURBANCE, OWNERSHIP, AND MANAGEMENT PRIORITY

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Active cave management, which represents any continuous action to conserve, restore, or protect a cave environment, is virtually non-existent in west-central Florida. This study focuses on developing an inventory to rank terrestrial caves in west-central Florida by management priority. A GIS-based cave inventory system, including a cave sensitivity index and cave disturbance index, were used as a tool to gain an understanding of the management priority of west-central Florida caves. The inventory was applied to 36 terrestrial caves in west-central Florida, which demonstrated a wide range of sensitivity and disturbance. The results show that by

relying solely on sensitivity and disturbance scores, management priority may not be accurately determined. Further examination revealed that ownership and management status also affect management priority. Consequently, cave sensitivity, disturbance, ownership, or management status does not solely indicate management priority. Rather, the management priority of caves in west-central Florida depends on a number of complicated, interwoven factors, and the goal of management must be examined holistically. Each cave must be individually examined for its sensitivity, disturbance, resources, management, and social and physical context in order to gain an understanding of management priority. Nonetheless, the cave inventory system developed for this project was used to gain a general understanding of which caves hold management priority, based on the cave manager's objectives. In order to ensure the conservation and protection of west-central Florida terrestrial caves, support from county or state government, combined with cave inventory data, is crucial in developing sound management policy.

SPELEAN HISTORY

SPELEOLOGICAL CLUES: FOLLOWING IN THE FOOTSTEPS OF JOHN AND WILLIAM BARTRAM, EIGHTEENTH CENTURY BOTANISTS EXTRAORDINAIRE

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The early naturalists of the United States were often descriptive of their geological surroundings. For example, well known Quaker botanist William Bartram referenced in his *Travels* numerous caves, springs, and other karst features of interest to the speleologist. While perusing John Bartram's 1765 diary describing his travels through the Carolinas, Georgia, and Florida, the author found a reference to a talus cave in Bladen County, North Carolina. Bartram wrote, "August 8, Walked out to Donahoos Creek to search for fossils with Billy [son William]... Sometimes ye creek would plunge down between vast rocks and not appear on ye surface for many perches unless in great cavities between ye rocks." No caves were listed for this county in the state cave survey. For that reason, in December of 2007, the author hiked the course of this remote creek to locate what the Bartrams had seen 242 years earlier. Not unexpectedly, the terrain had changed considerably. No large boulders or disappearing streams were found. Two theories are offered for the absence of Bartram's "vast rocks". They may have been quarried and used in the foundations of local houses. Also, the mouth of the creek had changed due to locks on the nearby Cape Fear River, so the boulders may be completely buried. Although Bartram's talus caves were not located, the search yielded the discovery of a new limestone solution cave along the same creek. Were it not for John Bartram's early description, chances are slim that a ridge-walk would have been considered there.

A NOTE ON THE HISTORY AND MATERIAL CULTURE OF BELLAMY CAVE, TENNESSEE

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Bellamy Cave is a large and well-known cave located in Montgomery County, Tennessee and currently managed as a biological preserve for the endangered Gray Bat. An examination of historical sources, and limited, initial investigations of the material culture on-site, allows the outlines of the history of Bellamy Cave to emerge. In the mid-to-late Mississippian period, Native Americans explored much of the cave. They also utilized it for mortuary and ceremonial purposes, as a clay mine, and perhaps as a habitation site. After Euro-American settlement, the cave was also utilized in a number of ways. The cave was an industrial space, serving as a moderate-to-large saltpeter mine in the war of 1812 era. Guano was also extracted for sale later in the nineteenth century. The cave was a cultural curiosity and social space, portrayed in the local press as a natural wonder and utilized as a place of public resort, including picnics and cave exploration. Bellamy Cave was also a hidden space, where the body of a

murder victim was deposited in 1882, which upon discovery led to a sensational and significant murder trial. Finally, Bellamy Cave was part of the household or domestic economy, used for storing food and possibly liquids, and also as a water source. Thus all five categories of use in the history of American caves are represented at the site. The current study suggests that the cave will reveal even more of its past with additional research.

REST IN PIECES: A CAVE INSIDE THE OLD MAN OF THE MOUNTAIN, FRANCONIA NOTCH, NEW HAMPSHIRE

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Sometime during the darkness of the early morning hours on May 3, 2003, the venerable Old Man of the Mountain of New Hampshire collapsed from natural causes. The Old Man, a rock bluff with the profile of a human face, was first noted in 1805 and was adopted as the official symbol of the State of New Hampshire by its legislature in 1945. It was one of the most recognized rock formations in North America and its likeness has appeared in books, posters, postcards, souvenirs, stamps, and the statehood quarter of New Hampshire. Although the demise of the Old Man was a sad event for the people of the Granite State, the memory of this iconic feature lives on. One of the most unusual and little known caves in New England existed within the rock mass comprising the Old Man's face. Like the profile, the cave has vanished, as the granitic blocks that defined its walls, floor, and roof now rest on the talus slope at base of Cannon Mountain in Franconia Notch State Park in the White Mountains. Although not visible from a distance, a small opening was noticed and sketched during a structural stability study of the Old Man formation in 1976 by Bryan K. Fowler, a New Hampshire engineering geologist. Based on this study, it is likely that the cave contributed to an overall weakness of the rock mass that eventually led to the collapse. The cave may even have had a pivotal role.

HISTORY IN GROTTO NEWSLETTERS

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By shelf-length, the grotto newsletters comprise the largest collection in the NSS Library. This collection contains a vital historical record of the chapters of the Society, and indirectly of the Society itself. However, the maintenance of this collection is becoming problematic. Many grottos are now publishing their newsletters online, and in some cases the Library is not receiving a paper copy to put on the shelf. An open question is whether it is desirable or practical to make a transition from shelved paper copies of the newsletters to an online collection on the Library webpage. The grottos must have a role in answering this question because copyright and public access policies differ from grotto to grotto. There is also the issue of whether back issues should be scanned and added to an online collection. A proposed solution would be for the Library webpage to provide publicly accessible sites where each grotto, using a specific password, could load its newsletters. Each grotto could also scan back issues and put them online. This potential solution leaves to each grotto the policy decisions of online publishing and access. The result would be a rich, online, historical resource for Society members and other scholars. When back issues for any grotto are scanned, another benefit would be the assurance that the content would not be lost due to deterioration of old paper copies or a catastrophe at the NSS Library.

WILLIAM KARRAS AND THE SPELEOLOGICAL SOCIETY OF AMERICA

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During the 1960s the National Speleological Society, like many other organizations, was challenged by members of society who rebelled against authority, laws, and regulations. Prior to this, the caving community had consisted of unique, sophisticated individuals who supported a scientific

structure for the NSS. However, it was rapidly changing into an organization with a majority of sport cavers. The younger generation wanted to have fun and generally wasn't interested in attending seminars at major hotels in Washington, DC. Most younger cavers were content with doing their own thing, but some desired to be leaders with many followers. The story of William G. Karras is an example of the internal struggles that occurred within both the NSS and the grottos. Karras led the formation of the Speleological Society of America (SSA) as an alternative organization; this was of great concern to the "bureaucrats" of the NSS due to the potential loss of revenue as well as the loss of national recognition. The effect of the publicity was to change many procedures of the NSS. Although William Karras's schism with the NSS attracted the headlines at the time, his tactics also served as a guide for others to follow.

SURVEY AND CARTOGRAPHY

SURVEY INSTRUMENTS: DIGITAL OR MANUAL? A FIELD COMPARISON OF RELATIVE ACCURACY AND PRACTICALITY OF USAGE

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This project served to investigate the use of digital hand-held devices compared against manual devices outside of traditional, professional surveying, in environments including caves. In recent years, the number and sophistication of hand-held surveying tools used in applications outside of professional surveying has increased. These tools have seen greatest use in construction and include laser range finders; digital inclinometers; and full-spectrum devices outputting distance, inclination, and azimuth. Specific devices include: Leica DISTO laser range finder, Shetland Attack Pony, TruPulse 200 range finder and inclinometer, and TruPulse 360 multi-function surveying tool. In the past, non-traditional surveying has been successfully conducted using survey tapes and hand-held manual survey instruments, such as Suunto liquid-filled precision compasses and inclinometers. While very cost effective, manual instruments are subject to a number of errors. These include recording blunders, instrument variability, and instrument-reader variability. Furthermore, accuracy when using manual approaches decreases as shot distances increase. Results of this work show that the above can be largely eliminated by using digital surveying devices. The most significant finding may be that errors from instrument-reader variability are nonexistent for well-aligned shots due to the deterministic nature of making measurements with digital survey devices. There are, however, two significant downsides to digital survey tools: (1) their unreliability in harsh environments, and (2) their high cost in comparison to manual precision instruments. The key conclusions of this work are that digital survey tools applied outside of professional surveying are accurate, reliable in most environments, and relatively easy to use.

U. S. EXPLORATION

NEW DISCOVERIES AT WATER SINKS CAVE, VIRGINIA

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A sinkhole, a mile long, receives drainage for much of the Burnsville Cove, a significant karst area that contains large cave systems in Bath County, Virginia. Prior to September 2008, a small cave was known to exist in the downstream terminus of the sinkhole. Late that month flood waters washed open a narrow fissure just inside the entrance. It was blowing a good breeze. When the fissure was widened to allow entry, a large passage was discovered extending beneath the smaller cave above. The first exploration/survey trip into the cave was unusual in that a small video camera was taped to the helmet of one of the survey team. With

183 meters of cable in tow the entire trip into virgin cave was viewed in real time on the surface. To date 3.52 kilometers of passages have been surveyed to reveal a complex multi-level maze. At the lowest level, a large stream upwelling from a deep pool, flows a hundred meters and then to another sump. This stream probably is the major portion of the sub-surface drainage of the Burnsville Cove. Nearly all of the cave's lower passages are washed clean from fast flowing flood waters. Leaves stuck to the ceiling near the entrance demonstrate the depth of flooding (50 meters). Video cameras have been placed in the cave and are remotely controlled from the surface. A subsequent video recording shows a flood event as it occurs inside the cave.

CAVES AND KARST OF THE ATLANTIC COASTAL RIDGE – MIAMI-DADE COUNTY, FLORIDA

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South Florida, unlike elsewhere in the continental United States, has experienced a near continuous deposition of limestone during the past 65 million years. The most recent of these limestones are associated with periods of higher sea-level during the Pleistocene and late Pliocene. The youngest of these limestones, the Miami Limestone, developed a relatively high, but low-relief topographic feature in southeast Florida called the Atlantic Coastal Ridge approximately 125,000 years ago. Collectively these Plio-Pleistocene limestones compose the critically important Biscayne aquifer. While groundwater scientists consider the Biscayne a karst aquifer, little information exists concerning caves in south Florida. In the late 1980s and early 1990s, Alan Cressler identified and produced rough sketches of 13 Biscayne caves. Recently, we began an effort to survey these caves in cooperation with, and with permits from, the Miami-Dade County Parks and Recreation Department and Everglades National Park. To date, we have surveyed nine caves. The longest surveyed cave, Fat Sleeper Cave, presently measures nearly 95.4 meters – an incredible length considering that the average passages in the cave are armoured with so called “razor rock” and measure less than 0.3 meters high. Fat Sleeper Cave, like many of the surveyed caves in south Florida, is located along a transverse glade that nearly bisects the Atlantic Coastal Ridge. These glade-related caves are vertically restricted to a specific zone in the Miami Limestone that is dominated by cm-scale-diameter, touching-vug porosity formed when the rock was deposited and enhanced into “razor rock” by the recent formation of the cave.

COASTAL CAVES OF PUERTO RICO

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Puerto Rico's coastal caves have long been overlooked in terms of exploration and documentation. A recent inventory of coastal caves has resulted in the exploration and survey of 68 caves. Located along the northern, western and southern coastal areas of Puerto Rico, many of these caves, due to their small size and relative obscurity, had been poorly defined in the course of previous fieldwork. Prominent sea cave (littoral) development was noted in all coastal areas examined but previously undocumented examples of flank margin caves were also identified within the Quaternary eolianite and adjacent limestone exposures along the northern coast. Spatial geometric analysis of completed maps of all caves examined also revealed that the 10 flank margin caves could be graphically segregated from the 58 sea caves by comparison of cave perimeter (ranging from 12 to 333 m²) to total cave area (ranging from 10 to 2862 m²). This project has revealed a surprising variety and abundance of cave along these dynamic and complex Atlantic and Caribbean shorelines, and the detailed spatial analysis of the coastal cave morphology was able to

determine speleogenic origin and quantify subsequent modification of these distinctive structures.

DIVING IN THE ICHETUCKNEE TRACE

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South of Lake City, Florida, Ichetucknee Springs State Park attracts tens of thousands of visitors to swim and drift in tubes in the gin clear water. The Ichetucknee Head Spring has very special position in history. It was a resting place on the Old Indian Trail and a place of sacred significance to later visitors. The Head Spring was also a watering stop on the Old Bellamy Road, which linked St. Augustine to Tallahassee. But the secrets of the Ichetucknee have an origin in a different time and place. The water that erupts from the springs, filling the banks of the river, begins its journey far outside the boundaries of the park. Far to the north, rain falls to the earth and soaks into the ground. In some places, rain-swollen creeks like Canon Creek drain into large swallet holes that refill thirsty underground conduits. Rose Creek and McCormick Sink, 11 kilometers north of the park are two of those recharge points. Scientists have conducted dye trace experiments to determine the extent of the recharge zones for Ichetucknee. Their work has confirmed that the Ichetucknee springshed is large and extends at least twenty-four kilometers north to Alligator Lake in Lake City, and the average age of water welling up in the springs is 15 years old.

RECENT EXPLORATION AT JEWEL CAVE

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With the completion of the Cave and Karst Management Plan in November 2007, exploration trips are now being led by several trained trip leaders, and exploration is being done throughout the cave. Previously the focus had been primarily at the periphery of the cave system. Since August 2007, nearly 4.8 km of passages were mapped. Over 1,600 meters were discovered on short, “close-in” trips, averaging 140 meters per trip. Over 2,400 meters were mapped on three overnight trips to the southeastern part of the cave. Although there were no breakthrough discoveries, this year's efforts have still resulted in a few leads that show great promise. Because of the climbing expertise among current explorers, more effort has been made to climb ceiling leads. Most of the PC Junction area has been mopped up, but there remain some leads to check, including one enticing ceiling lead. Recent rumors notwithstanding, Jewel Cave remains the second-longest cave in the world, with over 228.6 km surveyed as of June 1, 2008. The current mileage is always available at www.nps.gov/jeca.

RECENT EXPLORATION IN LECHUGUILLA CAVE, NEW MEXICO

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Since the last NSS Convention, extensive survey work has occurred in Lechuguilla Cave. Some expeditions focused on new exploration, while others were dedicated to resurvey and re-sketch so that complicated areas may be drafted onto the quadrangle maps. Work continues in all three branches of the cave. Lechuguilla has now passed the 200 kilometer mark with many promising leads to pursue. Two exciting breakthroughs in the past year have added mileage and renewed optimism that major extensions are still possible in this cave. Emerald City was discovered in the Western Branch by pushing a tight crawl. This opened into gypsum-lined trunk passage decorated with green minerals. This area continues to produce footage and features twin 60-meter domes at its end that are yet to be climbed. In the Far East, a tight belly-crawl and fissure series in the Outback was pushed to reveal the Northeast Corridor. Consisting of La Grange Hall, the Noreaster, and Northern Lights, this major trend breaks free of the Far East complex and is headed north. Northern Lights features impressive gypsum speleothems including swords, flowers, and

the first major display of chandeliers in the East. The area exhibits barometric airflow and all indications are that there may be many kilometers of cave to the north towards Big Manhole. Also in the Far East, exploration continues in Coral Sea, three years after its discovery. Much resurvey work has taken place in Chandelier Maze, the Near East, and Chandelier Graveyard, as cartographers attempt to graphically depict these complicated areas.

NASA SPACEWARD BOUND – CAVING FOR NASA FROM A HOT AIR BALLOON OR THERMOGRAPHIC ANOMALIES OF CAVE OR LAVA TUBE ENTRANCES FROM A RAISED PLATFORM

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Thermography of cave and lava tube openings is in its infancy. NASA and cavers have come together in the study utilizing infrared thermograms to locate caves and lava tubes. Research to determine which conditions and times are the best for subterranean entrance detection by use of infrared thermography and other detection methods is ongoing. A comparison of timed thermographic images in the infrared band of cave and lava tube entrances for NASA's Spaceward Bound program have resulted in answers, as well as more questions, concerning this state of the art method of locating cave and lava tubes on Earth and possibly other planets. Timed thermographic images of Cavernas de Quitor and other caves in the Atacama Desert, Chile caves were compared with Mojave Desert Lava tubes; Pisgah and Cima, as part of an ongoing NASA project to develop protocols to locate caves and lava tubes by their thermographic images. Research methods include analysis of thermographic images taken every ten minutes over a twenty-four hour period of the Cima lava fields in the Mojave Desert of California. By utilizing a hot air balloon as an airborne platform, a study is being conducted to determine the best times

and heights to obtain signatures of cave and lava tube openings. A number of factors are entered in and examined: Time of day, ambient temperature, height, dew point, distance, specific humidity, platform, as well as wind velocity and atmospheric gases. More NASA research is currently underway and cavers are starting to use building inspection infrared cameras in local areas to try to locate caves on their own.

WIND CAVE SURVEY PROJECT UPDATE – 2008, WIND CAVE NATIONAL PARK, SOUTH DAKOTA

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Since the 2007 NSS Convention, the Wind Cave survey project has continued to document new areas in Wind Cave. A total of 15 Wind Cave Weekends have been held since that Convention, where 5.53 kilometers were surveyed and inventoried during 47 survey trips. These trips averaged 118 meters of survey per trip and increased the official length of Wind Cave from 201.2 to 206.8 kilometers, maintaining its status as the fourth longest cave in the world. Some of the most interesting discoveries were made in the Gas Chamber area, which was pushed from the newly established Cosmos Camp in the Southern Comfort Section. This low impact camp was the first cave camp to be conducted in Wind Cave in nearly three decades. Except for the Gas Chamber area, the majority of the new survey was undertaken in the interior of the cave. Some of these discoveries included: Crumble Lane (currently at 199 meters); Chertstone Connection (currently at 551 meters); Fourteeners (417 meters); Snow Room (144 meters); and Fissure Kingdom (currently at 686 meters). In addition to the new survey, a project has been started to digitize the 36 Mylar cave quadrangle maps. To date, five quadrangles have been completely digitized. All new cave surveys are being added directly to these new digital computer maps.