

# Cave Research Foundation

## Annual Report 2008-2009





**Cave Research Foundation**  
**Annual Report**  
**2008-2009**

The Cave Research Foundation was formed in 1957 under the laws of the Commonwealth of Kentucky. It is a private, non-profit organization dedicated to facilitating research, management and interpretation of caves and karst resources, forming partnerships to study, protect and preserve cave resources and karst areas, and promoting the long-term conservation of caves and karst ecosystems.



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## Operation Areas and Managers

### Eastern Operations Area

*Dave West*

Mammoth Cave National Park

Cumberland Gap National Historical Park

### Lava Beds Operation Area

*Bruce Rogers and Pat Helton*

Lava Beds National Monument

### Ozarks Operations Area

*Mick Sutton*

Mark Twain National Forest

Ozark National Scenic Riverways

Missouri Department of Conservation

Missouri State Parks

Buffalo National Scenic River

### Sequoia/Kings Canyon & Mineral King

Operations Area

*John Tinsley*

Sequoia/Kings Canyon National Park

### Southwest Operations Area

*Barbe Barker*

Carlsbad Caverns National Park

### Hamilton Valley Operation

*Patricia Kambesis*

Hamilton Valley Field Station

Cave City, Kentucky

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Phil DiBlasi

### Newsletter Editor

William Payne

## Cave Research Foundation Awards

Each year Cave Research Foundation's Board of Directors and the Operation Areas Council review nominations of CRF members who have made significant contributions in terms of their participation and activity in the Foundation's various Operation areas and projects. Long-term contributions are accorded Fellowship in the Foundation. Participation and contributions to specific projects or local activities are awarded Certificates of Merit. Following is the list of awardees for 2008-2009. The CRF Board and Operation Areas Council appreciate the efforts of all CRF members without whose participation the work that CRF does would not be possible.

### *Fellows 2008*

Jonathan Beard OZ  
Dan Doctor SEKI  
Charles Fox EO  
Will Heltsley SEKI  
Kelly Holladay SW  
Jennie McDonough SW  
Richard Minert LABE  
Bob Taylor OZ  
Diana Tomchick  
Elizabeth Wolff LABE  
James Wolff LABE

### *Certificates of Merit 2008*

Bryant Bullard SW  
Dr. William B. Broeckel LABE  
William C. Devereaux LABE  
Ben Tobin SEKI  
Bill Weston SW

### *Fellows 2009*

Bob Alderson EO  
Ed Bobrow LABE  
Bill Broeckel LABE  
Bob Gulden EO  
Pat Helton LABE  
Elizabeth Miller EO  
Ken Story EO

### *Certificates of Merit 2009*

Virginia Bobrow LABE  
Brian "Beej" Hall LABE  
Daniel Gregor EO  
Matt Leissring LABE  
Heather McDonald LABE  
Cheryl Pratt EO

EO: Eastern Operation

LABE: Lava Beds Operation

OZ: Ozarks Operation

SEKI: Sequoia Kings Canyon Operation

SW: Southwest Operation

# Operation Area Reports

2008-2009



Berome Moore Cave- Perry County, Missouri

**Eastern Operation Area  
Annual Report**  
**Dave West**  
***Eastern Operation Area Manager***

In 2008, Eastern Operations at Mammoth Cave National Park fielded 159 parties, devoting over 12,900 hours to the park, and another 1,100 to the Biosphere Reserve outside the park in support of various projects as follows:

Many trips supported multiple objectives. Small Cave support continued with parties that inventoried and mapped Natural Tunnel, Stephen Spring Cave, Bourbon Cave, and Spined Spider Cave. Work continued with four parties in Wilson Cave, one in White Lightening Cave, and no less than eighteen parties worked in Great Onyx Cave.

Forty-four parties worked in Mammoth Cave, as efforts to complete all sheets for the main tourist routes continues to be a focal point. In other parts of the system, eleven parties worked in Unknown Cave, fifteen in Crystal Cave, nine in Salts Cave, twenty-three in Colossal Cave and six in Proctor Cave.

Efforts to move the database into Walls, the currently preferred data reduction software for the Cartography project, made significant progress, and all of the Mammoth data can now be run as a single project file. Efforts to combine this with the Roppel database have been complicated by Roppel's use of what have become duplicate Field Survey Book (FSB) numbers in that database. The February expedition was once again dedicated to database management and cartography. Elizabeth Winkler has nearly finished the Trip Report Database consolidation effort.

Charles Fox has completed a version of the Safety Video for use as a training tool by CRF. A bit more sound editing is needed before the video can be provided to the park for their use. A videographer that is creating a documentary about interpretive computer games received permission



Scenes from Mammoth Cave Photo: Peter & Ann Bosted

from the park to obtain footage in and around the Bedquilt section of Colossal Cave, and support was provided for this effort.

Eastern Operations also renewed its assistance to the park in the gating of Dennison Cave, the Cox entrance to Mammoth Cave (re-located last year), and the Watson's Trace section of Mammoth Cave, where numerous artifacts need protection. A new category called "Park Requested Support" was created for the last minute requests for logistical support received from the park that may require support for only a single trip. In this instance, we supported a dye tracing effort by providing a bit of training in caving techniques and route finding for a project being conducted by one of the park interns.

Outside the park, support for the CKKC survey in Roppel Cave has continued. Work also continues in the caves owned by Hamilton Valley neighbor and CRF member Stan Sides. A trip to Dogwood Cave on another neighbor's property searched for petroglyphs reported by a party visiting from Cuba, but which were not well described. Possible candidates were found and photographed for further examination.

In West Virginia, where efforts to resurvey Cave Hollow - Arbogast Cave (Tucker County) continue, in-cave work is pending a fully executed agreement with the U.S. Forest Service. It is hoped that the discovery of an ungated entrance to the system during the surface work con-

ducted last year as well as our ability to support the installation of a gate for this entrance will increase the priority of the work for the USFS. Many Eastern Operations members provided support for the gating of Trout Cave at the John Guilday Caves Nature Preserve, owned by the National Speleological Society. Buzz Grover really impressed the entire group with his ability to plan for and feed thirty people a day wonderful meals for four days.

During 2009, Eastern Operations at Mammoth Cave National Park fielded 144 parties, devoting over 14,535 hours to the park, and another 1,350 to the Biosphere Reserve outside the park in support of various projects as follows:

White Nose Syndrome (WNS) has provided a number of challenges to some of our projects. However, the Park continues to be very supportive of having our work continue during the general moratorium requested by the U.S. Fish & Wildlife Service. We are currently not pursuing objectives in known bat caves, nor are we beginning work in any small cave where work was not already ongoing. As requirements and guidelines change, we have adapted to meet the need.

Many trips supported multiple objectives. Small Cave support continued with parties that inventoried and mapped Crow and Hackett Caves. Work continued with two parties in White Lightening Cave, and no fewer than fifteen parties worked in Great Onyx Cave. Efforts to recover Floyds Cave continue. Forty-five parties worked in Mammoth Cave, as efforts to complete all sheets for the main tourist routes continues to be a focal point. In other parts of the system, thirteen parties worked in Unknown Cave, six in Crystal Cave, nine in Salts Cave, fourteen in Colossal Cave and fifteen in Proctor Cave.

Efforts to move the database into Walls, the currently preferred data reduction software for the Cartography project, made significant progress, and all of the Mammoth data can now

be run as a single project file. Efforts to combine this with the Roppel database have been complicated by Roppel's use of what have become duplicate Field Survey Book (FSB) numbers in that database, although Jim Borden proposes some kind of work around.

Elizabeth Winkler has finished the Trip Report Database consolidation effort. Charles Fox has completed a version of the Safety Video for use as a training tool by CRF and the park.

Eastern Operations also renewed its assistance to the park in the gating of Blight Cave, where Rafinesque Bats need protection. In April, support was provided to the park and WKYU for a video presentation. Support was also provided in Dossey Domes for airflow research.

Outside the park, support for the CKKC survey in Roppel Cave continued by seven parties until the moratorium was requested by USF&W. Eastern Operations ceased support for any work outside the park after the moratorium was announced, as no "sponsor" was available for it.

In West Virginia, where efforts to resurvey Cave Hollow - Arbogast Cave (Tucker County) continue, in-cave work seemed within reach. A new ecologist had joined the Monongahela Forest and was very interested in pushing the project forward. She joined myself and others for her first cave trip in West Virginia for a bat count only to find herself on the trip that confirmed the presence of WNS in the state. Needless to say, any hope of survey in Cave Hollow is on indefinite hold.

Gap Cave is looked upon as being at the gateway to the west for WNS. It initially closed to all work when the moratorium was announced. Hazel Barton established a research protocol for monitoring the bats for the presences of WNS which was then tried at Gap in an effort to establish a baseline prior to the arrival of the fungus. Following the lead of Mammoth Cave, other research resumed later in the year, and 26 cavers have brought the cave to a surveyed length of 14.657 miles.

## Cumberland Gap Project- Eastern Operation

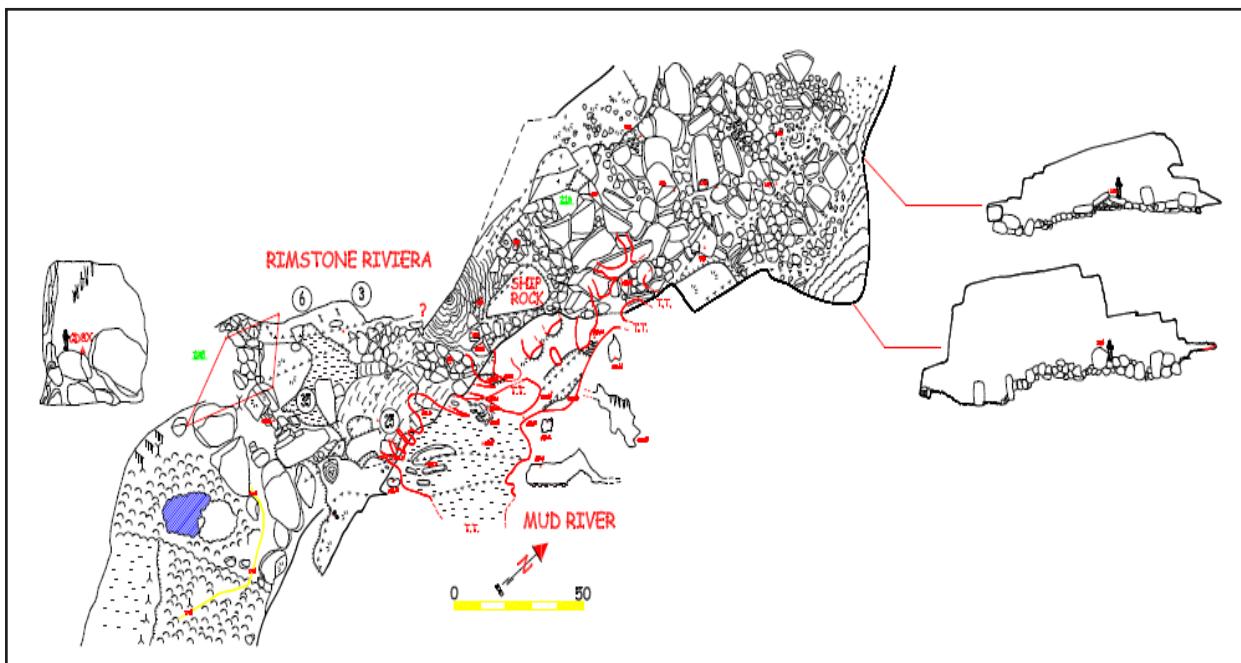
*Mike Crockett, Project Manager*

### *Introduction*

The Cave Research Foundation began a project to study caves and karst in Cumberland Gap National Historical Park in May 2003. Cumberland Gap is a natural feature that affords an easier migration route across the western ridges of the Appalachian Mountains. The gap in Cumberland Mountain is aligned with The Narrows, a gap 12 miles north in Pine Mountain. A meteor impact structure just north of Cumberland Gap allows for a few miles of relatively flat overland travel across the Yellow Creek Valley to Rocky Face, a transverse uplift that aligns with Cumberland Gap and the Narrows. These geological coincidences created a route for travel by animals and eventually people.

This interesting geological area is also rich in history. Kentucky's late Historian Laureate, Dr. Thomas Clark, listed Cumberland Gap as first on his list of sites that every Kentuckian should visit. Cumberland Gap National Historical Park, with Headquarters in Middlesboro, Kentucky was created in 1959 and is located in the states of Kentucky, Tennessee, and Virginia.

Gap Cave is the most significant cave in the Park. A substantial part of the cave is stream passage formed along the ~50 degree strike of Cumberland Mountain. The 30 to 50 degree northwestern dip is associated with the uplift of the southern edge of the Pine Mountain Overthrust Fault block. Gap Cave is characterized by wide steeply dipped stream passage and large breakdown filled galleries. 200 feet above



Rimstone Riviera Section of Gap Cave, Cumberland Gap Project. Cartography: Bob Gulden

the stream level about 1 miles of passage is formed along the axis of Rocky Face and is thought to be associated with that fault. Gap Cave offers interesting geology, rich history, and a significant cave with large and beautiful passages.

#### *Exploration Continues*

During 2008 survey totaling 8901.15 feet was completed. During 2009 survey totaled 6861.93. Gap Cave is now 14.959 miles long making it number 48 in the United States and number 165 on the world list of long caves. All known entrances to Gap Cave are in Virginia where it is the 5th longest cave. Substantial portions of the cave, including the very large room, are in Kentucky.

A total of 123 cavers have supported the project since 2003. During 2008 975.76 hours of volunteer time underground were invested. Total volunteer time underground during 2009 was 594.1 hours. During the life of the project 7194.99 underground hours and considerable surface time have been volunteered. Leads remain along the main survey line, upstream, and in the upper cave.

#### *The WNS Threat*

Prior to the government requested moratorium on caving in May 2009 entry into the caves

at Cumberland Gap by CRF was halted. White Nose Syndrome positive sites have advanced toward the Gap and most bat migration maps indicate substantial numbers of bats travel through the area. In cooperation with the National Park Service procedures were put into place to lessen the threat of gear and cavers at Cumberland Gap introducing WNS to the populations of bats. The wintering colony of Indiana bats near the Big Saltpeter Cave entrances to Gap Cave has not yet shown signs of infection. Advancing the survey upstream has revealed that more little brown bats use the cave than thought.

Since the wooden door at the main tour entrance was replaced by a bat friendly gate, a group of brown bats has started to winter near the tourist trail and now numbers over 200. The USGS installed a camera system in late 2009 to monitor this group.

Hazel Barton and a group of students gathered air, sediment, and direct bat microbial samples to develop a baseline prior to the expected arrival of WNS. The Park Service has provided vertical gear, laundry machines, pressure washing and other equipment to facilitate decontamination. Cavers are now required to certify compliance with the cleaning protocols.

## Ozark Operations Summary

*Michael Sutton,  
Ozark Operation Area Manager*

### 2008 Activities

CRF activities in the Ozarks in 2008 were diverse and extensive. We continue to collaborate closely with the Missouri Speleological Survey (MSS) and with individual NSS grottos. Almost all Ozarks Operations work results in additions and refinements to the detailed cave records maintained by MSS, and Scott House continues to act as curator of those records on behalf of MSS.

#### *Ozark National Scenic Riverways (ONCR) Cave Management*

Scott House continues to manage this productive, long-term project to map, inventory, and monitor the many caves of ONSR. Among other things, an interesting complex of caves in the Tunnel Bluff Natural Area were located and mapped. Mapping trips took place in two caves which are within ONSR statutory boundaries but are owned by Missouri Department of Conservation - both are fairly large, significant caves, and one of them, a gray bat cave, has not been fully explored. As with all CRF Ozark projects, database development and management forms a considerable part of the overall effort. CRF personnel continue to serve on the ONSR Cave Management Committee which meets periodically to discuss problems and to set priorities.

#### *Ozark National Scenic Riverways Restoration*

Cave restoration guru Jon Beard continued heading up a project to do major repair in some highly impacted caves at ONSR. Work continued on patching together a big mess of smashed dripstone in Bluff Cave, and a major clean-up took place in Lost Man Cave.



Tusher Hill Cave. Photo: Jim Cooley

#### *Mark Twain National Forest (MTNF) Bioinventory and Survey*

Funding for the project, which had been reduced to \$12,000 in FY2007, was restored to \$15,000 for FY2008. Even better, \$15,000 in MTNF funds have already been committed for FY2009 – this despite the USFS operating under a Continuing Resolution, a situation which has resulted in seriously delayed funding for the past several years. Thanks are due to our MTNF co-operators, especially our liaison person Gretchen Moore, for achieving this.

The main focus this fiscal year was, as always, on cartography and biology, but we have also branched out somewhat beyond these traditional aspects of the project. Jon Beard continued to head up an effort to do restoration in Onyx Cave, a past show cave now owned by MTNF – most of the work consisted of setting stepping stones over areas of spreading mud swamps to prevent further damage to the stream bed and to allow recovery to begin. Gary Johnson, the new editor of *Missouri Speleology*, is publishing a report from an earlier phase of the project, and requested photographs to accompany the article – this inspired Kansas City area cavers, led by Jim Cooley, to achieve extensive photo-documentation of caves on the Eleven Point District. Jim



Tunnel Bluff Shelter Cave Photo: Jim Cooley

has also located several “missing” caves in the Eleven Point’s Irish Wilderness, and come up with a few new caves in the same area. Cartographic efforts by Bob Osburn, Scott House, Ben Miller, Amy Crews, Bob Taylor, Jon Beard and Mick Sutton resulted in eleven completed maps and a number of preliminary drafts being turned in. Biological surveys were completed for seven caves.

Ozarks Operation cavers also assisted with field work for Matt Niemiller, who is studying the genetics of southern cavefish, and CRF’s own John Tinsley, who is looking into the possibility of dating major earthquakes by sampling quake-damaged speleothems.

#### *Fitton Cave Survey, Buffalo National River*

There was one survey trip to continue this long-term project, headed up by Andy Free. The trip resulted in an intensive cartographic assault on the Bat Cave entrance, with four survey crews extending the survey about 2,000 ft. from the entrance. The problem with absence of suitable housing has been solved for now, as we are able once again to use the Steele Creek facilities.

#### *Missouri State Parks*

What used to be the unfunded Fisher Cave (Meramec State Park) survey has been expanded into a more general project, funded by Missouri Department of Natural Resources, to work on

caves in Missouri State Parks. The initial phase of this expanded project called for mapping and bioinventory of a newly discovered passage in Onondaga Cave, one of Missouri’s premiere show caves. The survey of the 300 ft. passage was headed up by Ben Miller, and Ben has completed a nicely detailed map. The passage contains extensive paleontological remains, but is something of a biological desert. The next phase of the project calls for completion of the Fisher Cave map.

#### *Crevice Cave Biological Survey*

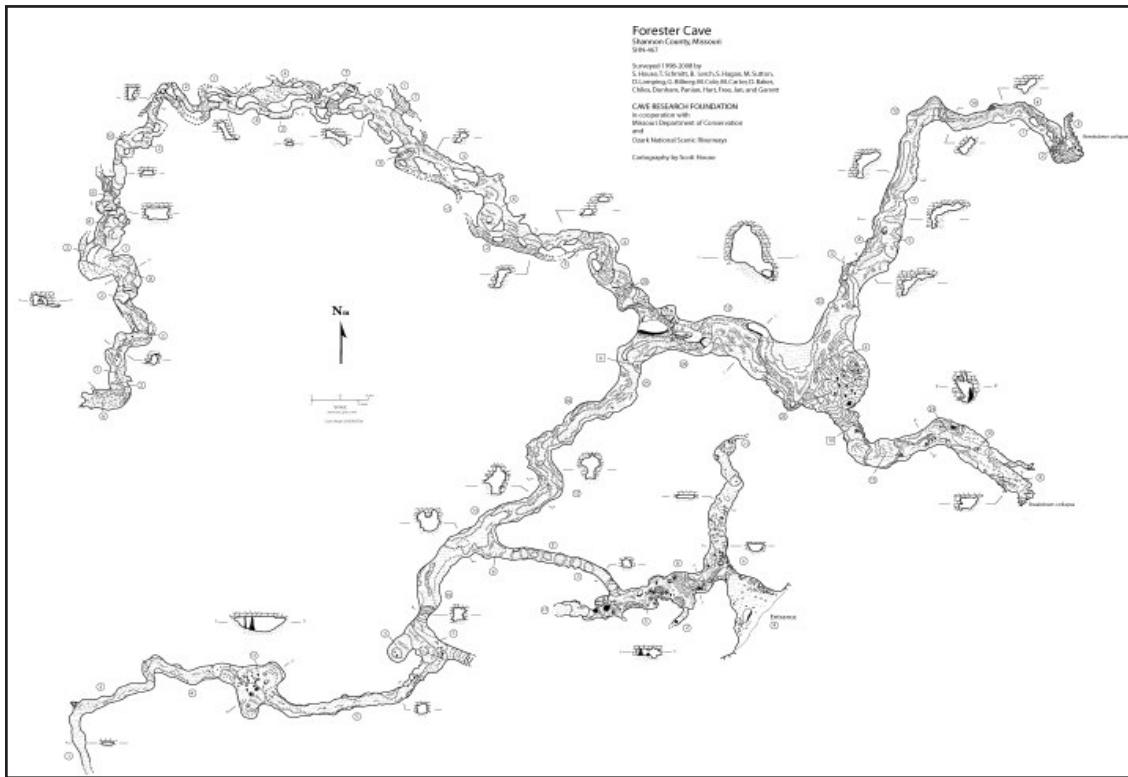
Seven trips were taken to continue the detailed biological survey of Missouri’s longest (c. 28 miles) cave. We focused on passages accessible from the Pipistrelle Entrance, with one trip taken via the Historic Entrance. The aim of the project is to cover a broad geographical area, assessing the faunal makeup of different passages and drainages in a semi-quantitative fashion, and to develop biologically annotated cave maps. The fauna list was expanded significantly, and interesting geographical variations continue to intrigue.

#### *Miscellaneous*

We continued our involvement in the annual YMCA “Becoming an Outdoors Woman” program with a beginner’s cave trip emphasizing biology and conservation. We also continued to assist Missouri Department of Conservation, US Fish and Wildlife Service and Bat Conservation International biologists in assessing the Indiana bat hibernaculum at Pilot Knob Mine.

#### **2009 Activities**

In 2009, the threat of white-nose syndrome started to make itself felt, even though Missouri is for now remote from any infected sites. Research activities are starting to see some constraints in terms of cave closures and precautionary decontamination procedures. We continue to collaborate with the Missouri Speleological Survey (MSS) and with individual NSS



grottos, especially with regard to additions and refinements to the cave files. Scott House continues to act as curator of MSS cave records on behalf of MSS.

#### *Mark Twain National Forest*

This year we bade farewell to our MTNF liaison, Gretchen Moore. We are grateful to Gretchen for keeping this project running and well funded throughout her tenure, and wish her the best in her new posting. Randy Long took up the slack on a pro-tem basis, and late in the year we welcomed a new MTNF hydrologist, Kelly Whitsett, who will be taking over cave research liaison duties.

Thirty-eight field trips took place (the same number as last year), covering a broad geographic area including the Ava, Eleven Point, Rolla/ Houston, Poplar Bluff, Potosi, Salem, and

Willow Springs Districts. The longest survey effort was in Chimney Cave, Washington County. The cave was first visited to follow up an observation of bats near the pit entrance, which turned out to be small clusters of little brown bats. Four subsequent survey trips mapped 1,100 ft of very muddy stream passage, with more to go, including even deeper mud holes. The cave is remarkable for a series of high domes, giving it an unusually active profile for an Ozark cave.

One party continued work along Cane Creek in Taney County, where there is a cluster of joint-maze caves – most of the longest cave, Cane Bluff Cave #2, was mapped and inventoried. Aquatic fauna was lacking, despite the presence of several pools, but terrestrial invertebrates were diverse and included a rare population of cave adapted harvestmen *Crosbeyella* sp. (This group

is currently undergoing revision.) Two side passages in extremely muddy Heuszel Cave (also in the Cane Creek drainage) were mapped, completing the survey and bringing the total length to about 2,300 ft. Neighboring Zoo Cave was also completed with one trip to mop up small leads. Nearby, the two C.C.S. Caves were mapped - cave no. 1 consisted of a wet and muddy crouchway ending in a low room; cave no. 2 was short, dry and low. The Math Branch Cave survey was continued with one trip.

A cluster of small caves along Crooked Creek, Iron County was visited over two trips. More accurate locations were obtained, unmapped caves were mapped, and all were biologically inventoried. The longest cave on the cluster had been previously mapped by a proto-CRF crew, and was now inventoried. Two small caves, including one new one, were mapped on the Poplar Bluff District, which is relatively lacking in known caves.

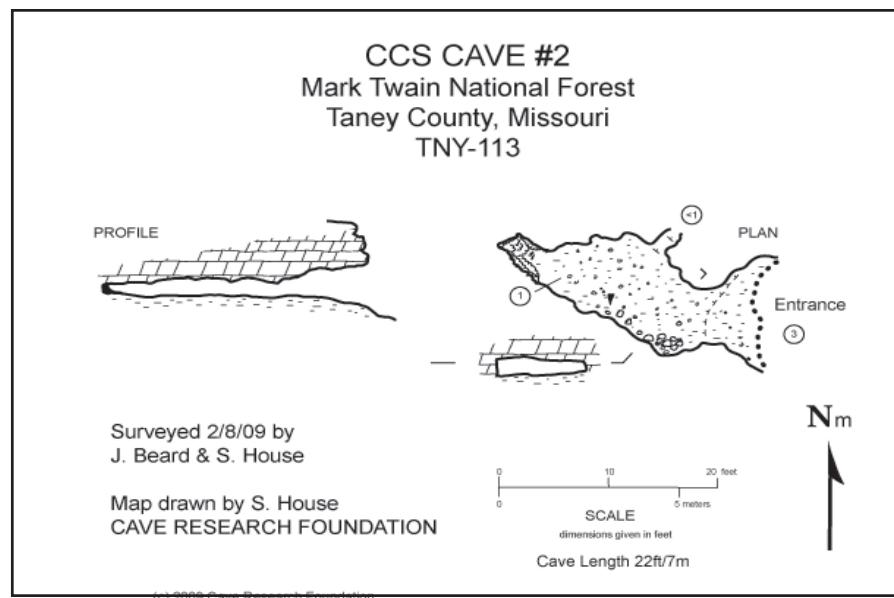
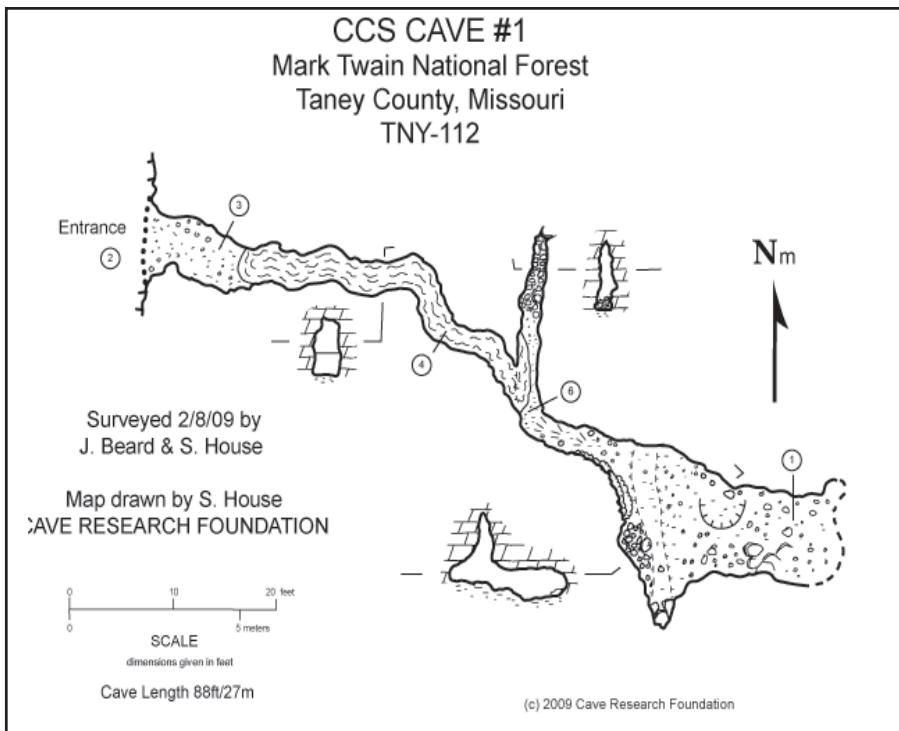
On the Rolla/ Houston District, Slot Cave was mapped, the Little Brown Branch Cave survey was completed. Two trips continued the survey of White Pine Cave – the second trip was supposed to finish up the last few low-level cutarounds but instead led to the discovery and mapping of a previously unknown passage. Two survey crews worked on the right-hand branch of Pittman Cave, mapping about 800 ft. of complex passage, and completing the survey of the 3,500 ft. long cave, while another group mapped and inventoried its smaller (240 ft.) neighbor, Little Pittman Cave. The cave is in the flood plain of the Gasconade River and subject to periodic back-flooding, resulting in a rich food source for a diversity of invertebrates. It also results in extremes of muddiness. The small entrance leads to a fairly large trunk, which despite the mud is well decorated with dripstone and flowstone. Like Pittman Cave, the passage ends upstream in a sump.

The survey of Pine Hollow Cave was completed with one trip to draw a longitudinal profile, and a biological inventory was done. The cave has an unusual (for the Ozarks) sinkhole entrance leading to a short but large fragment of trunk passage. It periodically floods to the ceiling, and contains large quantities of forest litter, fueling a high density of cave invertebrates.

The invertebrate assemblage included many of the usual suspects, but also included troglobitic trechine beetles, the most significant biological finding of the year. This group of beetles is widespread east of the Mississippi, but was long believed absent from the Ozarks - one of the mysteries of Ozark Cave biology. That situation changed in 2005 when CRF crews discovered populations of *Pseudanophthalmus* new sp. in two Shannon County caves. They remain extremely rare, even in the caves where they occur, and the Pine Hollow beetles are the first Ozark observation of *Pseudanophthalmus* beyond Shannon County. Since this population occurs in a different watershed, it may be a different new species than the Shannon County beetles, which are currently being described by taxonomist Thomas Barr. The setting is also very different – the Shannon County caves are much less nutrient-enriched and are not subject to major flooding.

On the Eleven Point District, Kansas City area cavers led by Jim Cooley continued to relocate missing caves, find unreported caves, and do photo-documentation. One interesting find was the collapse of Windy Pit in the Irish Wilderness, which has evolved into a broad sinkhole. One of the poorly located caves, Little Hurricane Cave, had been “missing” ever since J Harlen Bretz reported it with a vague location in his classic 1953 *Caves of Missouri* – the cave turns out to have an easily overlooked entrance. The Kansas City group also documented long-abandoned mines in the volcanic terrain of the Bell Mountain Wilderness and on the Ava District.

Along the North Fork White River, Douglas County, Turnbull Cave has a large entrance on private property, but most of the cave under-



lies MTNF land. Over one weekend, three mapping crews worked on extending the survey and a biological inventory was carried out. Several passages remain to be mapped but the upstream continuation seems unlikely to be passable for much further. Total mapped length so far is approximately 2,000 ft. The most interesting find biologically was another population of an unidentified harvestman, *Crosbeyella* sp.

Cave Hollow Cave (Iron County), an Indiana bat cave, was visited to develop a preliminary design for a gate to replace the present inadequate structure. Ozarks Operation cavers also continued to assist with field work for Matt Niemiller's (University of Tennessee) study of the genetics of southern cavefish, and for CRF's John Tinsley (US Geological Survey), who continued

his earthquake-dating study by sampling anciently broken straws from Camp Yarn Cave (Carter County).

Maps were completed for Arch Cave, Bay Nothing Cave, Brady Cave, Carter Cave, C.C.S. Caves 1 and 2, Dry Cave, Dry Shelter, Hamilton Cave, Little Bowman Cave, Little Pittman Cave, Overhang Cave, Rat Dome Cave, Twenty-three Degree Cave and Wasp Cave. Preliminary drafts were prepared for Angus Tunnel, Cane Bluff No. 2 Cave, Chimney Cave, Heuszel Cave and Pittman Cave.

Management assistance took the form of extensive work on enhancing the MSS records on MTNF caves, and in assessing active Forest management areas for nearby privately owned caves which might be affected by management activities.

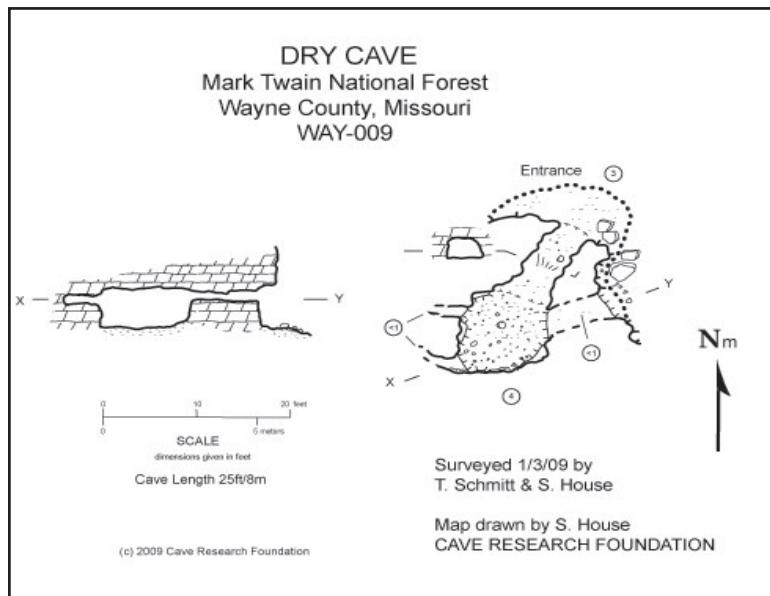
#### *Missouri Department of Conservation*

Final surveys of Banker Hollow Cave in Shannon County were finished by Dan Lamping and other members of Meramec Valley Grotto in a cooperative project. The map of Forester Cave

was finished. This interesting cave ended at 2,800ft (850m). Also a survey was started of Helm Cave in Wayne County. About 150ft of survey was done. A start was made on a final draft of the Powder Mill Creek (PMCC) Cave map. PMCC is one of the longest caves in the Ozarks, with about 8.8 miles, most of it in very well decorated stream passage. The computer draft, by Mick Sutton, is based on Doug Baker's detailed pencil draft, and will take up four large sheets at a 1:600 scale.

#### *Missouri Department of Natural Resources*

The surveys of Fisher Cave, a large cave in Meramec State Park, are nearly finished. Current surveyed length is 11,320 ft (3,450m) Trips were taken to the upstream of Weeping Willow Spring Branch to map a canyon side passage and to finish the large Hugh Dill Room. This section of the cave is reached through the Hugh Dill water-crawl, which becomes an ear-dip in places. The drafting on this map is continuing. Sections of the cave reflect some faulting or shear zones; investigations into this could result in some interesting findings.





Heep Cave Ice Pond, Lava Beds National Monument  
Photo: Bruce Rogers

Lava Beds National Monument is located in Siskiyou and Modoc Counties in northern California at an elevation of about 5,000 feet. The Monument has the largest concentration of lava tube caves (over 750 as of November, 2008) in North America. . The 38,000 year-old Basalt of Mammoth Crater and the 10,850 year-old Basaltic Andesite of Valentine Cave hold the majority of the lava tubes in the Monument. Lava Beds was established as a U.S. National Monument on November 21, 1925 and extends over (and under) 46,000 acres of high desert. Lava Beds National Monument also includes Petroglyph Point, one of the largest panels of American Indian rock art in the United States. This phreatic cone erupted through ancestral Tule Lake some 275,000 years ago and is now bordered with hundreds of carvings dating to about 4,000 ago. In addition, the Monument manages a WW II German and Italian POW camp as part of its historical holdings. This last summer a new, multi-site WW II theme National Monument was created. Since part of it is centered on the Japanese-American Interment camp in nearby Newell, it appears the Lava Beds will assist in managing this as well.

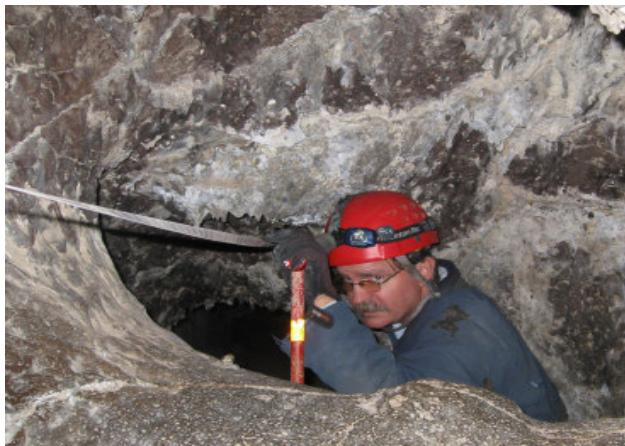
During the last 12 months, more than 30 CRF cavers have participated in Cave Research Foundation activities in Lava Beds National

## Lava Beds National Monument

*Pat Helton and Bruce Rogers,  
Co-Operation Area Managers*

Monument. There have been five major expeditions to the Monument plus many smaller trips. Well over 3000 person hours were spent on site by CRF cavers; nearly as many more hours were spent off site working on cave maps, planning expeditions, writing reports, etc.

The main thrust during 2008 has been surveying and inventorying known caves in the Monument. The National Park Service (NPS) staff had requested we focus our efforts to the semi-developed caves in the general area of the new Visitor Center and adjacent Cave Loop where much of the caving done by Monument visitors takes place. Lava Beds Chief Cartographer Rich Steiger, in cooperation with Shane Fryer, the Monument's physical scientist (and CRF JV), dispatched trips to complete well over 13,000 feet of cave, much of it in the large Labyrinth Cave System located in the Cave Loop area adjacent to Monument Headquarters. A small amount of exploration and survey remains to be completed in this major lava tube system. In the meantime, we have started a detailed survey of Sentinel Cave, another large lava tube that is stacked 4 layers deep. The initial six survey expeditions have already located new passage and the level of detail gathered will enable the pro-



Jim Wolf pulls tape surveying in Sentinel Cave in Lava Beds National Monument. The strong and variable magnetic field in the 36,000 year-old basalt of Mammoth Crater effects magnetic compasses so much that the compasses must be perched atop 0.3 meter long wooden dowels.

Photo: Matt Leisring & Heather McDonald

duction of a highly detailed map for a visitor handout (see below).

Additionally, there were trips to smaller caves throughout the Monument throughout the year; many led by Bill Devereaux who is also a Volunteer in Parks at Lava Beds. CRF work parties completed surveys in several caves that were previously “nearly” complete and conducted cave features inventories as well. The remaining task is to draft up final maps of these smaller caves to current standards.

Bill Devereaux led many other trips to relocate nearly a dozen new or “lost” caves throughout the Monument. Reconnaissance cards were filled out for all these sites and several caves were mapped as they were discovered.

In addition to these tasks, several days of work were undertaken to assist Dr. Bill Broeckel’s CRF-Modoc National Forest Operations Area. These two areas adjoin each other, however, the Modoc effort is often lacking in sufficient personnel to make major efforts in locating, mapping, and inventorying the numerous lava tubes present. On several Lava Beds Expeditions, CRF cavers were detailed to work in the Modoc Forest Ops Area and assist with those efforts.

Work continued to be led by Bill Devereaux on the Ice Level Measurement, Cave Reconnaissance, and Cave GPS Location and Monumenting projects. On-site Manager Bill Devereaux also started looking over lesser-known ice caves with an eye of possibly incorporating

them into his ice levels project. Some progress was also made in the General Inventory project. Current protocols require the cave features inventory to be carried out as parties survey lava tube passages, thus we are considering deactivating this older project. Coordinated by Brian “Beej” Hall and Marc Hasbrouck, work was begun on a pocket size photographic feature booklet to be used by CRF cavers inventorying lava tube features. This will allow inventory takers to be sure they identify all features in the lava tubes with certainty. Eventually this may become a stand-alone publication for purchase by Monument visitors.

CRF also informally inspects the gates on several major, delicate caves for the NPS. This summer one major cave gate was found breached and CRF cavers “realigned and stabilized” about a quarter of a ton of basalt blocks and slabs to prevent unauthorized visitors from bypassing the locked gate and entering the cave.

In addition to his many other hats, Bill Devereaux also participated in a summer Lava Beds open house wherein he portrayed Judson D. Howard, the “Father of the Lava Beds.” JD, as contemporaries knew him, was an early explorer of the caves.

Pat Helton’s Cave Names project was given a big boost with the accessing of records in the Shaw Library at Oregon Technical University. Several trips to that establishment netted a large number of records and documents written by or about Judson D. Howard regarding his ex-



Rich Steiger, Lava Beds Chief Cartographer, sets up a stadia rod for lava tube surveying in Sentinel Cave with Mary Rose (left) and Glenn Hasbrouck while Eileen Belan takes notes in the right background. The large cave is very popular with Monument visitors. Photo: Bruce Rogers.

ploits from about 1920 to 1940 exploring the “Modoc Lava Fields,” as the area in and around Lava Beds Nat. Mon. was known nearly 100 years ago. “JD,” as cavers and NPS staff know him, was instrumental in exploring, naming caves and other features and also marshalling Congressional support for creating the Monument in November of 1925.

On one trip to Lava Beds, “Beej” came into contact with a group of “retired” cavers who were from the now disbanded “Spelunking Unlimited” group based in nearby Klamath Falls, OR. These cavers spent considerable time working in the Monument in the late 1950’s through the early 1970’s. We notified the NPS staff of their whereabouts and now these pioneer local cavers will be part of the oral history interviews to be started by the Monument staff this fall. Several of their large format maps were located in the NPS cave map files (see below) and will be placed in suitable storage to prevent deterioration.

Bruce Rogers made a start on legal page-size handouts for several of the most popular caves in the Monument for the Interpretive Division. This includes Skull Cave and Sentinel Cave, two of the most popular caves with visitors. Working with the Lava Beds Interpretive staff, these free handouts will be made available to Monument visitors in lieu of a Ranger-led trip to some caves. Eventually these will be used to pro-

duce a short guidebook about some of the more popular caves in the Monument. The 1990 USGS Bulletin by Waters, Donnelly-Nolan, and Rogers will soon be out of print and will not be reprinted, thus leaving a gap in the available literature for the general public.

A major effort led by Pat Helton and Rich Steiger was completed in the NPS large cave map files. This corpus of cartography spanned about over 80 years of mapping work by at least eight different groups working in the Monument. Several hundred cave maps were sorted and entered into a database for the NPS and CRF’s use in determining which caves had been mapped, which hadn’t, and which still needed additional work.

At the urging of Ops Co-Managers Helton and Rogers, the NPS regional Office made several presentations to several California National Speleological Society Chapters about the Monument’s General Management Plan (GMP), now under revision. Many Lava Beds CRF personnel also commented on the new GMP and encouraged and assisted NPS personnel in making presentations to several NSS Grottos in the Central California area. On one expedition, several of the NPS planners were taken underground to sample the variety of lava tubes existing in the Monument. CRF personnel also started assisting the Lava Beds staff in revising their Cave Management Plan with an evening presentation to expedition members that lasted well past the allotted time the Monument staff thought might be needed for comments.

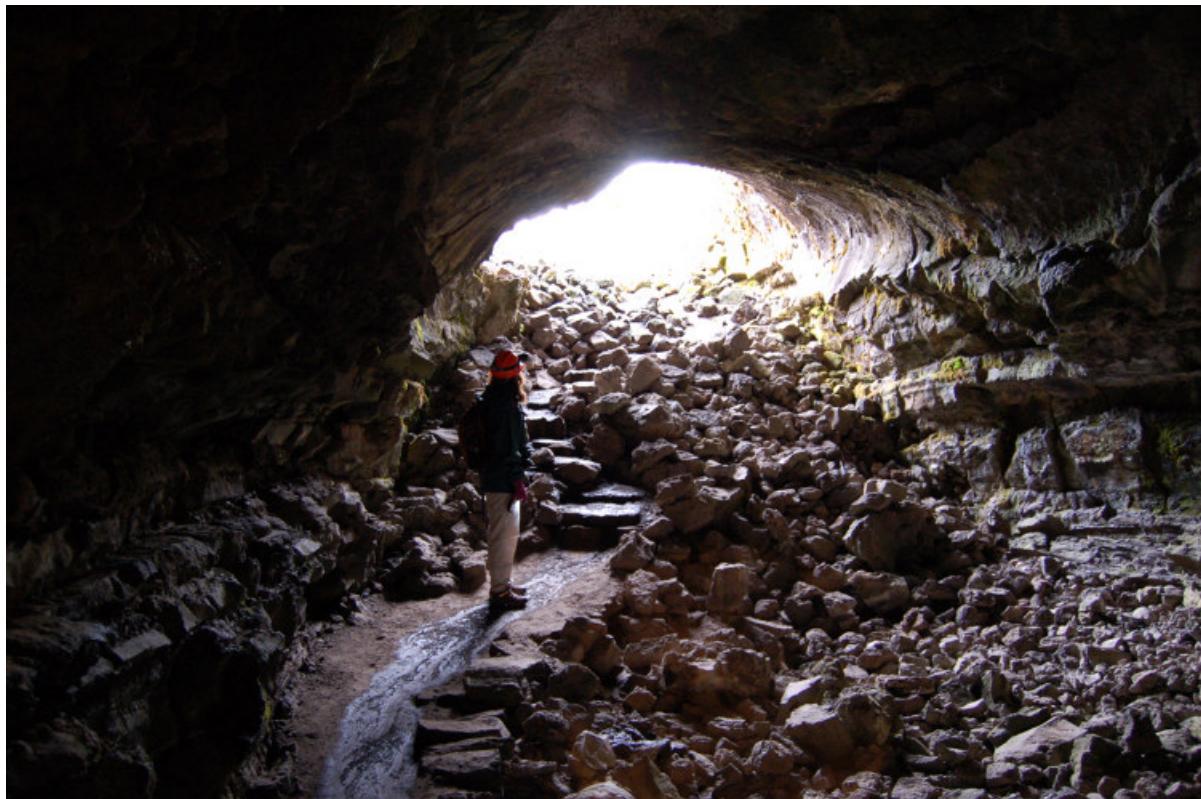
As part of our partnership activities, the Monument staff asked us to guide a reporter from a regional newspaper around to several ice caves and talk with them about what changes we'd seen in the ice caves for an article on climate change the newspaper folks were writing.

CRF also played a role in the repair of the new Research Center early in 2007. Components of the RC fire suppression system required replacement and Lava Beds Chief Cartographer Rich Steiger, a former Naval facilities architect, was able to cooperate with the NPS staff and find suitable replacements.

The CRF-designed and -built Research Center itself continues to be a major attraction of the Monument and surrounding Klamath Basin for researchers, educators, and conservation-oriented groups. The facility has been in nearly constant use since its dedication in early 2005. CRF

and the NPS are continuing to refine operations procedures for the facility. Newly signed-on CRF JV's Tonya and Samantha Vanover utilized the Center for Tonya's Western Washington University lichenology Master Thesis fieldwork over the summer and fall months. Other visitors included classes in earth science and archaeology from University of California Santa Barbara and several other colleges and universities in Northern California, and three other NPS researchers and Volunteers in Parks working on both the Lava Beds General Management Plan and the NPS Night Skies Program.

As word of CRF's work at Lava Beds spreads throughout the Western States, we look forward to new JV's who will augment the core of dedicated CRF cavers to ensure another productive year at Lava Beds. The planned 2009 CRF National Expedition at Lava Beds in the fall will highlight this next year.



Lower entrance to Sentinel Cave, Lava Beds National Monument. Photo: Barb Butler

## Sequoia and Kings Canyon National Park (SEKI) Operations Summary

*John C. Tinsley, SEKI Operation Area Manager*



Roger Mortimer in the Lake Room  
Photo: Bill Frantz

The CRF project at Sequoia and Kings Canyon (SEKI) National Parks maintains projects in hydrology (B. Tobin and J. Tinsley), sedimentology (J. Tinsley), exploration and cartography (J. Mosenfelder), infrastructure (H. Hurtt and P. Nelson), structural geology (M. Cichanski), and exploration (M. Scott). Within the Parks, we remain active in the karst of Redwood Canyon, including Lilburn Cave and Big Spring, and in the Mineral King area of alpine karst where we conduct mainly cartographic and inventory studies on the caves there as snow conditions permit at 9000-11000 feet. This year, one of us (Tinsley) completed a hydrologic geochemical snapshot of Hidden Spring, located southwest of Muir Grove, which represents a successful effort by CRF personnel to expand operations beyond the areas in which we traditionally have been active. Additional studies are planned to start in 2010 in Redwood Canyon and in cooperation with the Cave Management Specialist. Also, Ben Tobin is commencing his Ph.D. research addressing the contributions of karst and other bedrock aquifers to the surface water budget within the Kaweah River drainage, and we look forward to a productive research endeavor with him during the next 3 years.

The advent of legal wilderness status in Redwood Canyon and efforts by SEKI management to bring local management practices into conformity with the requirements of the Wilderness Act, the National Environmental Protection Act (NEPA) and other pertinent regulatory legislation means that the research-station based operations in Redwood Canyon will need some modification. Cave Management Specialist Joel Despain has done an exemplary job of helping us to prepare for potential changes in management practice. The research presence in Redwood Canyon will be handled as part of an Environmental Assessment process required for approval of a new and revised Cave Management Plan presently being prepared by Joel Despain and Chief of Resources Management Charisse Sydoriak and others. This effort is probably another year or perhaps two away from completion. In the interim, CRF is reducing the visible infrastructure associated with the Lilburn field station to the minimum required to do the NPS-approved research. Some of these changes are purely cosmetic, such as removing the stones used to line the trails extending upstream in Mays Creek drainage, relocating tables to positions behind the cabin. Others are substantial, such as removing 24 feet of 18-inch diameter corrugated conduit pipe from the Big Spring area that was trucked

in during the late 1960s and was used to construct a stilling tower for a float that was part of a Leupold & Stevens analog stage recorder used for decades to monitor stage at Big Spring. Inexpensive and reliable digital piezometer equipment will be installed and will not intrude on the viewscape; thus, we no longer need the stilling tower. It has always been an eyesore, and all concerned are going to be delighted to see it go.

Supporting the infrastructure in Redwood Canyon is always an ongoing challenge. The recent complication involved having to relocate the solar array from where it has been for 25 years. The SEKI hazard tree crew responded to the Ops Manager's request to remove trees that could have fallen on the cabin. During that visit, the tree carrying the solar panels was identified as being rather diseased with several maladies, including "butt rot". Howard Hurtt conducted surveys to locate suitable alternate trees, located the best choice, and supervised the successful relocation of the solar array. Mark Scott took the initiative to reduce the clutter within and under the research station. Many expedition participants left the expeditions more heavily laden than when they arrived and hundreds of pounds of unneeded material has been removed and disposed of properly outside the now wilderness of Redwood Canyon.

At Mineral King, Roger Mortimer completed the draft cave map showing the survey of White Chief Cave in White Chief Basin. A surface survey linking more than 25 potential entrances was completed and one expedition was



Howard Hurtt and Fofo Gonzalez repairing phone line. Photo: Bill Frantz

dedicated to connecting the cave to as many of these potential entrances as possible. Two expeditions were directed at mapping and inventorying caves in karst areas located north of Timber Gap, where remoteness, steep terrain, and a short field season conspire to limit frequent visitation and exploration.

Look for short detailed summaries by the SEKI principal investigators elsewhere in this report.



## Hamilton Valley Operation Report

*Pat Kambesis,  
Hamilton Valley Operation Area Manager*

Sign at the entry way to the Hamilton Valley Research Station, Cave City, Kentucky

Photo: Pat Kambesis

CRF's Hamilton Valley Research Station (HV) continues to serve as Eastern Operations main field base in the Mammoth Cave area. In addition it sees active use by university groups, karst-related researchers, Mammoth Cave National Park (MACA), Kentucky Speleological Survey, Roppel and Whigpistle exploration teams, Western Kentucky University/Mammoth Cave Karst Field Studies Program, as well as a site for workshops, symposia and meetings.

### *Land and Facility Management*

The Hamilton Valley Land Management Committee (HVLM) sponsored two annual work-weekends in 2008 and 2009 at the facility. A core group of CRF members, mainly from Ohio and from local CRF members are the mainstay of the work weekends. Their projects included buildings and trailer maintenance, repair, and cleanup, road, trail, and fence maintenance and upkeep, and in general keeping the grounds in good shape. In addition to the two work weekends, HVLM committee members make visits and repairs as necessary throughout the year.

HV is enrolled in a government program that supports the planting of native grasses. Preston Forsythe has been overseeing this project.

Pesticides were used to get rid of some of the pesky non-native plants and then Roundstone Seed planted a variety of native grasses. It will take a few years to make a noticeable difference but according to Preston, things look good so far.

HV continues to receive property income from a number of sources. USDA Farm Service Programs, Conservation Reserve Program, CREEP (Sinkhole/native grasses and flowers), Tobacco Transition Payments, and Hunting Lease.

### *Special events*

In April 2008, HV hosted two Cuban cavers who visited for a week. They participated in a CRF expedition, went on several specially-arranged MACA park tours, and gave lectures at HV on their work in Cuba.

In October 2008, HV co-hosted with MACA, the Max Kaemper Symposium. This was a 3-day event that featured two days of presentations at HV, an evening social, a concert in Mammoth Cave and a cave tour for Max Kaemper's family to those placed that Kaemper visited during his mapping activities at Mammoth Cave at the turn of last century.



Entry way to the main building at Hamilton Valley Research Station Photo: Pat Kambesis

In July of 2009, HV hosted a post International Congress of Speleology Field trip at the Mammoth Cave area. We had 20 international participants who spent the week caving in the area.

#### *New Building*

Cave Books is planning on adding a new addition to the HV buildings that will house some of the inventory for Cave Books and the CRF library. Location is yet to be determined and building plans are in progress.



Bob Hoke on kitchen duty during EO expedition



CRF members relaxing in the main hall

Photos: Pat Kambesis

## Cave Research Foundation National Expeditions



Mary Rose in Valentine Cave, 2009 National Expedition to  
Lava Beds National Monument. Photo: Bern Szukalski

## Slaughter Canyon Cave Resurvey Carlsbad Caverns National Park, New Mexico

*Pat Kambesis*

Team members: Pat Kambesis (expedition leader) Scott House, Patti House, Andy Free, Spike Crews, Joyce Hoffmaster, Dave West, Karen Wilmes, Daniel Greger, Ann Kensler, Steve Ormeroid, Judy Ormeroid, Matt Goska, Josh Brewer, Mick Sutton, Sue Hagan, Perry Frantz, Bill Frantz

**Objective:** To finish the resurvey and resource inventory of Slaughter Canyon Cave

*Prelude:*

The purpose of this expedition was to finish the resurvey of Slaughter Canyon Cave that was started in 2004. It also served as Cave Research Foundation's first national expedition. Since most everyone in the group had no experience with doing resource inventory, we spent October 26, 2008 in McKittrick Cave, BLM land, to give everyone an orientation on resource inventories and to the challenges of sketching in mazey boneyard. Because of our 16-person-day limit in Slaughter Canyon Cave (we had 18 expedition members), we also fielded one team per day to McKittrick Cave so that everyone could cave every day if they chose.

In order to make the most of the five days allocated to the Slaughter Canyon resurvey, we assigned teams to specific sections of the cave (second big fissure, Black Forest, Main passage, side leads off of main passage). We also, for the most part, kept the teams intact since once a group starts to work together they are more efficient if they keep working together. Because of the size and complexity of the passage, sketching tasks were split and one team member did plan and another did profiles and cross sections. One person was dedicated to resource inventory. We also tried to keep the trips to no more than 8 hours in length so we could keep up a caving-every-day schedule.



Judy Ormeroid in Black Forest Fissure  
Photo: Bill Frantz

*October 27, 2008 – 1727 feet surveyed*

The morning was spent in orientation with Paul Burger and Dale Pate who went over park rules and survey standards. Afterwards the teams got survey equipment, paper, flagging tape, pencils, markers and pencils for the survey work at hand. All surveyors entered the cave at 12:30pm and split into four teams. The Second large fissure was assigned to Scott House (plan), Spike Crews(profile/cross sections), Andy Free (inst./tape) and Patti House (inventory). It took them a while to find their intial tie-in station but once they did they set 11 stations into a northwest

trending alcove off of the main fissure. Several areas (B105, B107A) were not checked completely because of the delicate nature of the passage. This team set 11 stations and completed 345 feet of survey. Dave West (plan), Judy Ormeroid (profile/cross sections), Bill Frantz (inst./tape) and Karen Wilmes (inventory) were assigned the Black Forest fissure. They set a tie-in station in the main passage and began working up the slope and into the dauntingly large fissure passage. Because of the size of the fissure, they did a loop survey in order to accurately define the passage width and to get good passage detail. They set a total of 11 stations and 421 feet of survey.

The large trunk passage was reserved for Mick Sutton (plan) who has a lot of experience atmapping big cave. The rest of the team was composed of Ann Kensler (profiles/crosssections). Sue Hagan (inventory), Steve Ormeroid (inst/tape). They began their survey outside of the fissure that House et al were working and tied to B100 to start the R survey. They worked their way in-cave setting 10 stations and 473.6 feet or survey. Daniel Greger (inst/tape) and Pat Kambesis(sketch/inventory) tied to F1 and worked their way back toward Suttions team and eventually tied in.

Because Daniel did not feel that he knew enough about cave features of the Guadalupe Mountain caves, Pat took over the inventory duties. They also surveyed to the beginning of an upper level cutaround to the main passage. They set a total of 9 stations and did 488 feet. Once back at the cabins and after shower and dinner, survey data was entered in Compass format.

*October 28, 2008 - 3,133.5 feet surveyed*

On this day, everyone entered the cave between 8:30-9:00 to begin their day. Scott House's team continued mapping the main trend of the Second large fissure. They noted a ladder at B112 and several climbing and other leads. They finished off the fissure with a total of 23 stations and mapping 1100 feet. Dave West, Karen



Dave West, Karen Wilmes and Judy Ormeroid in Black Forest Fissure Photo: Bill Frantz

Wilmes, Judy Ormeroid and Bill Frantz picked up where they left off the previous day and continued mapping/inventory in the large, nicely decorated fissure which mercifully narrowed down toward its end. Several upper leads were noted. The team set a total of 15 stations and added 481.5 feet to the days' survey total. Mick Sutton, Ann Kensler, Sue Hagan and Steve Ormeroid leap-frogged ahead of F1 and resumed the big passage survey with station R8. Unfortunately this made a hanging survey but the plan was to tie up the loose end on the next survey day. Mick and his team were challenged by the large passage dimensions and the profusion of significant cave features which are different than what they are used to encountering in the Mammoth Cave System (where they do most of their CRF work). They set a total of 15 stations and covered 926 feet of ground. Matt Goska (sketch), Joyce Hoffmaster (inst/tape), Josh Brewer (inventory) tied to E4 of Kambesis/Greger survey into the upper level cutaround to the main passage. This area led to two overlooks down into

the main passage and ended in a fissure alcove. A total of 16 stations and 626 feet of survey was added for the day. After dinner, showers and some relaxing, data entry resumed. There were four blunders identified in the survey and slated for correction on the next day.

#### *10/29/2008 – 3,340 feet surveyed*

All teams entered the cave between 9-10am. The priority of the day was to unhang the R survey and correct blunders. Mick Sutton, Ann Kensler, Sue Hagan and Steve Ormeroid continued mapping the main trend all the way to the area of the Clansman. The passage was quite sizeable and large speleothems were common. Sutton's team set 19 stations with 759 feet of large passage survey.

Scott House, Spike Crews, Andy Free and Patti House proceeded to the back of the cave and began survey of the Monarch fissure, starting at the Monarch. They had large complex passage to map with lots of floor detail. With Scott suffering from sketcher burnout they terminated their survey without completing the fissure. They put in 11 stations and 530 feet. Pat Kambesis and Joyce Hoffmaster unhung the Sutton survey, picked up some wall definition near the F1 area, and then headed farther in-cave to see where help was needed. They surveyed some small passages near the Clansman area, finished the Chinese wall room, picked up the second smaller fissure that parallels the Monarch Fissure, and finished the last 4 shots of the Monarch fissure. Their station count was 28 and 1265 feet of passage. Matt Goska, Daniel Greger and Josh Brewer were tasked with picking up any side leads off of the main passage and they found their calling at R10 where they finished up another small fissure. They then headed to the Monarch area to tie in with House's and Kambesis survey. This was Matt's first try at mapping really big passage and it took

him a while to get over the initial shock of BFP. At Y12 they were not able to clearly define the wall (see lead list) because the area was heavily decorated and would require climbing on and walking over flowstone (they did not bring their flowstone shoes). The team picked up 25 stations and added 786 feet to the survey. Dave West, Karen Wilmes, Judy Ormeroid and Bill Frantz returned to the Black Forest fissure to map the last remaining area – a balcony overlook into the main passage. They tied to Sutton's survey (R17) and completed their section of the cave. They set a total of 13 stations and added 514 feet. At the end of the day, the efforts of all teams completed the bulk of the survey of Slaughter Canyon Cave.

#### *10-31-2008 114 feet surveyed*

After perusing the sketches, it was determined that there was a "hole" in the sketches near the B100 area and also that a small passage was missed. A team consisting of Ann Kensler, Judy Ormeroid and Daniel Greger returned to the area and cleaned up the remaining survey. Perry Frantz and Bill Frantz accompanied the team and took photos. A total of 114 feet of passage was mapped.

#### *Epilogue*

The CRF National expedition mapped a total of 8,295 feet of passage that completed the resurvey of Slaughter Canyon Cave. Some leads remaining, many of which are climbing leads. Of interest is the end of the Monarch fissure which does have air – the passage got tight and had formations, but it also continued upward so could probably use another good look. One passage near the entrance was not completed so that should be added to future objectives lists for the cave.

## Scenes from the 2009 National Expedition at Lava Beds National Monument

**Participants:** Bruce Rogers, Pat Helton, Ed Bobrow, Virginia Bobrow, Kaedean Doppelmayr, Marc Hasbrouck, Heather McDonald, Matt Leisselring, Scott House, Patti House, Bill Devereaux, Liz Wolff, Jim Wolff, Diana Tomchick, Joke Vansweevelt, Mary Rose, Beej Hall, John Tinsley, Bill Broeckel, Judy Broeckel, Rich Steiger, Bill Frantz, Peri Frantz, Charles Fox, Karen Willmes, Dave West, Bern Szukalski, Pat Seiser, Joyce Hoffmaster, John Lovaas, Bob Hoke.

The 2009 National Expedition was held at Lava Beds National Monument in California. Expedition objectives included the surveys of Hercules Leg Cave, Juniper Cave, Sentinel Cave, A.H. Cave, Township cave and Gale Cave. Surface work was conducted near Valentine Cave and Hardin Butte. Photomonitoring was continued in Symbol Bridge, Big Painted Cave and Valentine Cave. CRF contributed a total of 2582 person hours, with 8,039 feet of survey and cave inventory and photodocumentation.



Back from a successful cave hunt: (l. to r.): Brian "Beej" Hall, Ed Bobrow, Jim Wolff, Mary Rose, and Marc Hasbrouck. Photo: Bern Szukalski

At lunch time in Juniper Cave, (L. to r.) Scott House (MO), Mary Rose (CA), Diana Tomchick (TX), and Joke Vansweevelt (CA) take a break amid the flotsam of cave surveying.

Photo: Bruce Rogers



Marc Hasbrouck, Jim Wolff, and Ed Bobrow pose for Bern Szukalski at another new cave found while hiking in the Valentine flow in the Monument.

Photo: Bern Szukalski

Scott house thumbs the notes while Bob Hoke stands ready for the next shot in T. Cave. Photo: Bern Szukalski



Karen Willmes really enjoys ambling down the colorful passages of T. Cave as one can clearly see in this photo by Bern Szukalski

The Saturday night BBQ after the CRF National Board meeting. Front table, clockwise from bottom: Kaedean Doppelmeyr, Marc Hasbrouck, Joyce Hoffmaster, Charles Fox (CRF Dir.), Diana Tomchick (CRF Dir.), Bob Hoke (CRF Treas.), Patti House, John Lovass (CRF Dir.), Scott House in cap (CRF Pres.), Pat Seiser (CRF Dir.), Mary Rose, Dave West (CRF Eastern Ops Mgr.), Karen Willmes, John Tinsley (SeKi Ops Mgr.). Back table from lower right: chair, Jim Wolff, Rich Steiger, Judy Broeckel, Bill Broeckel, Peri Frantz, Bill Deveaux (hiding under table), Pat Helton (Lava Beds Ops Mgr.) Bern Szukalski (CRF Sec.), Brian "Beej" Hall, Bill Frantz, Liz Wolff, Virginia Bobrow, Ed Bobrow.

Photo: Bruce Rogers



# Earth Sciences



Collapse of the major feeder tube in the 36,000 year-old Basalt of Mammoth Crater form spectacular trenches that wind across the landscape of Lava Beds National Monument. Rich Steiger and Brian “Beej” Hall stand atop the entrance to glacier Incline Cavern, which is host to many Violet-green back swallows. Photo: Bruce Rogers.

# Hidden Spring—A Long-Known Resurgence with a Newly Identified Carbonate Aquifer Chemistry in Sequoia and Kings Canyon National Parks, California, USA

John C. Tinsley, III<sup>1</sup>

<sup>1</sup>*Cave Research Foundation, 1040 Oakland Avenue, Menlo Park, California 94025-2206 USA*

## Abstract

Hidden Spring, a perennial alluviated resurgence shown on U.S. Geological Survey topographic maps, discharges <3.8 L/s into a tributary to the Kaweah River's North Fork, and lies along a line that connects Big Spring in the Redwood Canyon karst and Crystal Cave in the Yucca Creek karst in Sequoia and Kings Canyon National Parks (SEKI). The spring thus lies between two major karst areas of the Parks and along a trend that subparallels the structural grain of the Sierra Nevada. The prior literature is mute on Hidden Spring's chemistry and discharge; published geologic maps show no exposures of marble or other carbonate rocks, but the spring has served as a reliable source of water for stock and for domestic use during the 20<sup>th</sup> century. In June 2008, Cave Research Foundation (CRF) personnel hiked to Hidden Spring via trails unmaintained for at least three decades. Using standard U.S. Geological Survey protocols water samples were obtained for dissolved inorganic carbon (DIC), major cation and anion chemistry, and stable isotopes D, <sup>18</sup>O and <sup>13</sup>C. The significant cation concentrations reported in units of mg/L are Ca (41) and Mg (23) and the only anion of significance is HCO<sub>3</sub> (lab alkalinity of 242). The specific conductance of 330 uS/cm and DIC values (4.05) are in excellent agreement with the pH of 8.1 and are consistent with the lab alkalinity being essentially all HCO<sub>3</sub>. The chemical characteristics are those expected of groundwater that flows through dolomitic rocks. The Redwood Mountain pendant carbonates hosting Lilburn Cave are known to range in composition from calcite- to magnesium-rich marble. The rocks contributing carbonate to Hidden Spring are neither gypsic nor sulfide-rich as SO<sub>4</sub> concentration is but 0.68 mg/L. The sample is high in silica (SiO<sub>2</sub>

= 42 mg/L) but that would be consistent with considerable contact with silicate or calc-silicate rocks, which are abundant locally and regionally as non-carbonate pendant lithologies. The stable isotopes and the DIC values, specific conductance, and major element abundances support a carbonate aquifer association, with strong evidence of contact with silicate rocks. What is not discernible from the chemistry alone is the distribution of carbonates relative to calc-silicates hence the true nature of the carbonate occurrence remains obscure. Alternatively, the marble that is the apparent source of the bicarbonate hydrochemistry of Hidden Spring may simply not yet be exposed owing to vagaries of erosion or to geologic structure, or more likely, the carbonate is distributed as many small masses within the larger body of metamorphic rock. Hidden Spring thus drains a heretofore unrecognized carbonate terrane of uncertain extent and thus may or may not constitute an additional area of the Parks with cave resource potential.

## Introduction

Sequoia and Kings Canyon National Parks (SEKI) in the southern Sierra Nevada of California are famous for deep canyons, rugged mountains and numerous groves of Giant Sequoia trees. The bedrock geology exposes mainly Jurassic and Cretaceous batholithic rocks, the roots of a middle to late Mesozoic continental volcanic arc that developed along a convergent plate margin that persisted for tens of millions of years along the western margin of North America. These batholithic rocks range in composition from diorite to granite and intrude early Mesozoic and older marine sedimentary and volcanic country rock that contained pods of marine limestone. In

the modern landscape, the areas of metamorphic rock are not contiguous and commonly are termed *roof pendants*. Parts of six of these metamorphosed rock terranes are mapped in the Giant Forest quadrangle by Sisson and Moore (1994) and the carbonates are metamorphosed to marble. The discontinuous bodies of marble harbor more than 250 caves and karst features that together make SEKI not only a “mountain and tree” park, but also a “cave” park.

USGS topographic maps show Hidden Spring drains to the North Fork of the Kaweah River. Historically the spring has provided water for stock and for domestic use as nearby now-abandoned roads and cabins attest. The geologic map of the Giant Forest 15' topographic quadrangle (Sisson and Moore, 1994) shows the spring to lie along a trend that subparallels the regional tectonic grain of the Sierra Nevada and connect two major karst areas. Northwest of Hidden Spring is the Redwood Mountain pendant, with the Redwood Canyon karst that contains Lilburn Cave and its ebb-and-flow resurgence (Big Spring). Southeast of Hidden Spring lies the extensive Crystal Cave Pendant and the Yucca Creek karst, the parks’ show cave, Crystal Cave, and many other karst features. Yet, the literature contains no information about Hidden Spring, its chemistry or its discharge. Sisson and Moore (1994) map the spring near the contact between the granite of Skagway Grove and a body of biotite-feldspar-quartz schist commonly containing andalusite or sillimanite. They note these poorly exposed rocks also contain minor marble, calc-silicate schistose rocks and thin layers of micaeous quartzite. The contact between the granite of Skagway Grove and the above metamorphic rocks is mantled with alluvium (Figure 1).

To further evaluate Hidden Spring as a potentially unrecognized karst aquifer, personnel of the Cave Research Foundation visited the spring in June 2008 and obtained water samples to analyze for major cation and anion chemistry, dissolved inorganic carbon (DIC), and stable isotopes D, <sup>18</sup>O and <sup>13</sup>C thereby obtaining a snap-

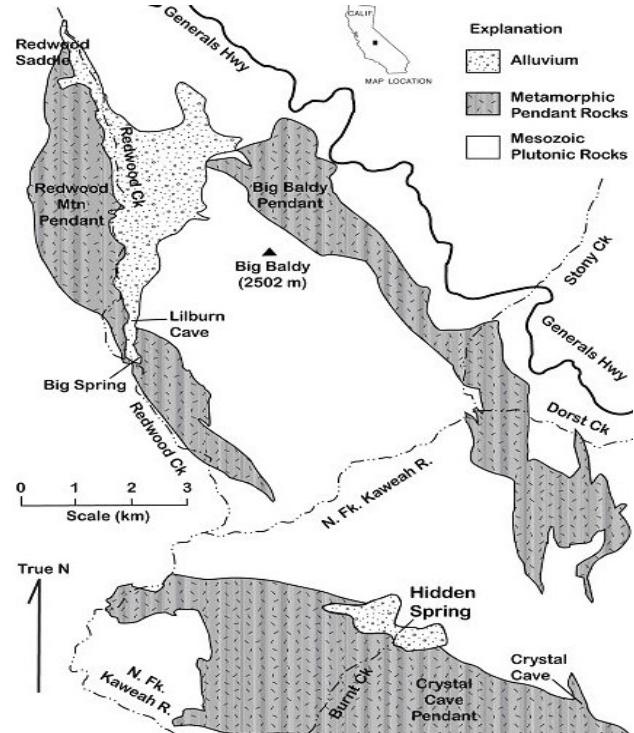


Figure 1 Map showing generalized geology, plutonic rocks, pendant rocks, selected physiographic features and cultural features near Hidden Spring, Sequoia and KingsCanyon National Parks. Abridged from Sisson and Moore (1994).

shot of this spring and its chemistry. Standard U.S. Geological Survey water sampling protocols were used (per Evans *et al*, 2002, p. 294-295). For additional comments on methodology and discussion of findings please see Tinsley (2009).

## Results

The field measurements and laboratory analyses for Hidden Spring are compiled in Table 1, along with selected values from Big Spring/Lilburn Cave for comparison (Urzendowski, 1993). For dilute water, ppm concentrations effectively equal mg/L within analytical accuracy. It is important not to over-interpret sparse data.

For Hidden Spring (Table 1) the geochemical snapshot from sample 2008-JCT3-HS shows that significant cation concentrations are: Ca (41 mg/L), Mg (23 mg/L) and SiO<sub>2</sub> (43 mg/L). The charge balance (5.42%) is satisfac-

tory and shows no indication of sampling or analytical problems or issues. The only anion of significance is  $\text{HCO}_3^-$  (lab alkalinity as  $\text{HCO}_3^- = 242 \text{ mg/L}$ ). The specific conductance of 330  $\mu\text{S}/\text{cm}$  and the total DIC value (4.05) are in excellent agreement with the pH of 8.1 and are consistent with the lab alkalinity being essentially all  $\text{HCO}_3^-$ . Elevated silica is not surprising as abundant silicate lithologies characterize rocks upslope from the resurgence. Extracted versus calculated DIC values are 4.00 mmol/kg and 4.05 mmol/kg, respectively. The DIC extracted from both pre-evacuated sample tubes is in decent agreement with the quantity expected from the values of field pH and lab alkalinity, and shows good internal consistency in the sampling and analytical processes and confirms that alkalinity is essentially  $\text{HCO}_3^-$ .  $\delta\text{D}$  values are  $-80.7 \pm 2$  per mil and  $\delta^{18}\text{O}$  values are  $-11.64$  per mil for sample 2008-JCT3-HS.  $\delta^{13}\text{C}$  measured on 2008-JCT3-HS7 is  $-14.33$  per mil.

Both these springs have significant values of Ca,  $\text{SiO}_2$ , and alkalinity as  $\text{HCO}_3^-$ . However, Hidden Spring is carrying nearly thrice the silica and more than thrice the  $\text{HCO}_3^-$  concentration as was Big Spring. Big Spring has significantly lower concentration of Mg compared to Hidden Spring and a bit more sulfate. Pyrite is known from Redwood Canyon where there is minor sulfide mineralization observable along the contact separating pendant carbonates from intrusive plutonic rocks on the east side of Redwood Creek. Hidden Spring apparently lacks much sulfur-based mineralization. Probably the silica, magnesium, and calcium differences are significant for these two hydrologic systems, with a greater preponderance of dolomitic carbonates characterizing the Hidden Spring system compared to Big Spring's more classic  $\text{CO}_2\text{-H}_2\text{O-CaCO}_3$  chemistry.

The isotope data and the DIC values, specific conductance, and major element abundances seem most consistent with a closed system carbonate aquifer component to the Hidden Spring hydrologic system, with evidence of contact with

		Hidden Spg			Redwood Cyn	
		2008-JCT3-HS			Big Spring	
		30-May-08			8-Mar-92	
Cations						
Na	ppm	mg/L	6.1		2.5	
K	ppm	mg/L	1.3	meq/L	0.7	
Ca	ppm	mg/L	41	2.05	19.4	
Mg	ppm	mg/L	23	1.89	0.8	
Fe	ppm	mg/L	<1		na	
SiO <sub>2</sub>	ppm	mg/L	43.2		15.3	
Li	ppb	ug/L	<3		na	
Mn	ppb	ug/L	<1		na	
Al	ppb	ug/L	84		na	
B	ppb	ug/L	30		na	
Mo	ppb	ug/L	<1		na	
V	ppb	ug/L	2.4		na	
Ba	ppb	ug/L	20		na	
Sr	ppb	ug/L	97		na	
As	ppb	ug/L	<2		na	
Rb	ppb	ug/L	1.2		na	
Cs	ppb	ug/L	<1		na	
U	ppb	ug/L	<1		na	
		meq/L cations	4.2511			
Anions						
F	ppm	mg/L	0.08		na	
Cl	ppm	mg/L	1.39		0.6	
Br	ppm	mg/L	<0.01		na	
NO <sub>3</sub> -N	ppm	mg/L	0.04		na	
SO <sub>4</sub>	ppm	mg/L	0.68		1.3	
PO <sub>4</sub> -P	ppm	mg/L	<0.01		na	
Alkalinity as $\text{HCO}_3^-$	ppm	mg/L	242		67.5	
	meq/L	Anions	4.0268			
	balance %		5.42			
Water temp	deg C		9.1		6.0	
Field pH			8.1		7.6	
Field conductivity	uS/cm		330		107	
				Urzendowski (1993)		
DIC (extracted)	mmol/kg			2008-JCT3-HS-7	2008-JCT3-HS-8	
DIC (calc)	mmol/kg		4.05	4.00	3.98	
delta 13C per mil				-14.33	-14.37	
SI calcite			0.41			
SI dolomite			1.89			
Other Isotopes			delta	uncertainty		
delta D per mil			-80.7	-2		
delta 18O per mil			-11.64	-0.2		
<sup>14</sup> C (% modern C)					75.41	

Table 1

Geochemical data from Hidden Spring, Sequoia and Kings Canyon National Parks, sampled on June 3, 2008. Some geochemical data from Big Spring/ Lilburn Cave/Redwood Mountain pendant included for comparison.

silicate and calc-silicate rocks. Not apparent from the chemistry alone is the distribution of carbonate lithology relative to silicate and calc-silicate rocks in the bedrock traversed by waters feeding Hidden Spring. The chemistry indicates a mix of carbonate and silicate rocks nourishes Hidden Spring, but whether the carbonate component consists of a large body of cave-bearing marble or is distributed as small marble lenses within silicate and calc-silicate rocks remains unresolved. Sisson and Moore (1994) noted small quantities of marble occur in the schist component of the pendant rocks, although these marble occurrences are not mappable as individual marble bodies.

## Conclusions

Water from Hidden Spring apparently reflects the composition of the local rocks as described and mapped by Sisson and Moore (1994). Carbonate rock (likely dolomitic marble) in contact with Hidden Spring waters likely account for the significant calcium, magnesium and  $\text{HCO}_3$  values. However, the fairly negative  $\delta^{13}\text{C}$  value for DIC suggests that weathering of silicate rocks, soil  $\text{CO}_2$  and weathering processes (and not solely marine carbonate rock as a DIC source) influence the water of Hidden Spring. Hidden Spring's chemistry has more to it than a classic karst aquifer with waters in contact solely with calcareous carbonate rocks. The likelihood of finding extensive karst resources associated with Hidden Spring seems small, given the proximity of extensive areas of plutonic rocks at elevations above the resurgence and the relatively high levels of dissolved silica.

## Acknowledgements

The author is indebted to personnel of the Cave Research Foundation, including Steve and Barbara Ruble and William Frantz who sampled Hidden Spring in autumn of 1994. The sample deserved a better fate, folks. Thomas Mathey, Mark Conover, Michael Cooper and Anne Rosinski gamely accompanied the author and assisted with the procurement of new samples in June 2008. The Resources Management and Cave Management staff at SEKI granted pre-season access to Dorst Campground and thereby simplified our field logistics. Dr. William C. Evans of the US Geological Survey, Menlo Park, CA provided analyses and helpful interpretive commentary; Dr. David J. DesMarais of NASA-Ames and Dr. Daniel H. Doctor (USGS, Reston, VA) provided insights concerning pitfalls and interpretation of carbon isotopes. However, all errors of inference and interpretation herein are the author's.

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## **Sedimentology of the Redwood Canyon Karst**

*John C. Tinsley, Principal Investigator*

Since the late 1970s, CRF personnel have conducted sediment mapping and monitoring above and below ground in the Redwood Canyon karst. These studies continue unabated. After several years of being included with a federally-funded fire ecology and nutrient study headed by Dan Doctor (and reported on in past CRF Annual Reports), the sedimentology project will sail ahead again under its own banner and proposal. These studies use the sinkholes of the karst as local sediment traps and measure the rate at which sediment is delivered to the sinkholes. As the National Park Service proceeds with its plans to reduce the high fuel loads in Redwood Canyon with a series of prescribed fires, the cave sediment personnel eagerly await the burning of parts of the landscape containing sinkholes. As these areas are burned, the sediment study will monitor sedimentation in the sinkholes to gauge the

impact of burns on rates of sediment yield to these small karst basins. Comparisons of several basins should provide a robust statistical picture of the impact of fire on sediment yield at the ground surface in this mixed oak/conifer forest at about 5000 feet elevation in the southern Sierra Nevada.

Studies of sediment transport in Lilburn Cave during the past 32 years have demonstrated that the El Nino winters provide the greatest increase in water levels above Big Spring and that during these winters is when the greatest quantity of sediment moves within and through Lilburn Cave and the resurgence at Big Spring. We continue monitoring sediment movement within Lilburn Cave and below Big Spring, noting a slow progressive accumulation of alluvial deposits temporarily stored in bars and channels within local basins in the karst.

## **Structural and Metamorphic Geology of the Redwood Mountain pendant, Sequoia and Kings Canyon National Park, California**

*Dr. Marek Cichanski*

*De Anza College, Cupertino, CA*

Solution caves in California are predominantly formed in marble rather than in limestone. Marble forms through the metamorphism of limestone, commonly during mountain-building events at convergent plate boundaries. Lilburn cave, California's longest, is a prime example of an extensive cave system developed in a mass of marble. My research is aimed at elucidating the history of the marble and other metamorphic rocks in the area of Lilburn cave.

Although the Sierra Nevada hosts a number of marble caves, metamorphic rocks (such as

the marble) are very much the exception rather than the rule in Sierran geology. The vast majority of the bedrock of the Sierra consists of granitic rock, which formed through the intrusion, cooling, and solidification of large masses of magma. Most of these magma bodies intruded and solidified during the Mesozoic Era. (As an example, 90 million years is a common age for many Sierran granites.) Although most of the pre-existing 'country rock' was replaced by granitic rock, small masses of these older rocks remain from place to place. Such masses are often re-



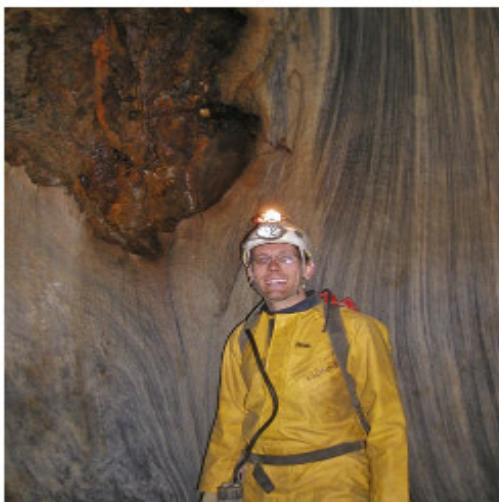
Photomicrograph of a thin section of quartz-biotite schist from the Redwood Mountain roof pendant, near Lilburn Cave. Field of view is approximately 1cm across. (Photomosaic by Marek Cichanski)

ferred to as 'roof pendants', because they were originally envisioned as flag-like masses that hung down into the molten magma. Many of them, however, are probably better envisioned as 'walls' or 'screens' between the granitic intrusions.

One such pre-granitic mass is the Redwood Mountain pendant. Lilburn Cave is developed in a small, steeply-inclined mass of marble within the Redwood Mountain pendant. Most of the pendant consists of quartz-biotite schist,

quartzite, and fine-grained, biotite-rich rocks which lack the well-developed micaceous foliation that would be typical of a classic 'schist'.

My research project involves examining outcrops of the metamorphic rocks of the Redwood Mountain pendant, including the bedrock exposed in Lilburn Cave, to try and work out the history of these rocks. They began as sedimentary rocks, probably on the Paleozoic continental-shelf margin of western North America, and were deeply 'underthrust' below miles of other rock when convergence began between North America and the plates of the Pacific Ocean basin. The plate convergence that caused this underthrusting occurred during the Mesozoic Era, and also resulted in the production of the magma that became the granite of the Sierra Nevada.



The 'Giant Black Inclusion' in Lilburn Cave. The dark rock is a piece of non-carbonate rock that behaved in a relatively brittle fashion during the deformation and metamorphism that formed marble from a pre-existing mass of limestone. While the banded marble flowed in a ductile fashion, the non-carbonate rock fractured into discrete masses called boudins, such as the one shown here. (Photo by Sarah Jones)

# Late Pleistocene California droughts during deglaciation and Arctic warming

Jessica Oster

Cave Research Foundation Grant Recipient Report

Recent studies document the synchronous nature of shifts in North Atlantic regional climate (e.g. Alley et al., 1993; Labeyrie, 2000; Bond et al., 2001; Broecker, 2003; Hemming, 2004; Kienast et al., 2006), the intensity of the East Asian monsoon (e.g. Wang et al., 2001; 2005; Yuan et al., 2004), and productivity and precipitation in the Cariaco Basin (e.g. Peterson et al., 2000) during the last glacial and deglacial period. Yet questions remain as to what climate mechanisms influenced continental regions far removed from the North Atlantic and beyond the direct influence of the inter-tropical convergence zone. I have developed uranium-series calibrated isotopic ( $d^{18}\text{O}$ ,  $d^{13}\text{C}$ , and  $^{87}\text{Sr}/^{86}\text{Sr}$ ) and trace element ([Mg], [Sr], and [Ba]) time series for a stalagmite from Moaning Cave on the western slope of the central Sierra Nevada, California that document changes in precipitation that are approximately coeval with Greenland temperature changes for the period 16.5 to 8.8 ka.

The Moaning Cave proxy records reveal repeated millennial- to sub-century climate shifts throughout much of the last deglacial period (Figs. 1 and 2). Stable isotope fluctuations recorded at Moaning Cave share many features that appear coincident with interhemispheric-scale climate changes revealed by Greenland ice cores, northern and southern European speleothem and lacustrine records, southeast Asian and Brazilian speleothems, and eastern Pacific and Caribbean marine sediments (Stuiver and Grootes, 2000; Wang et al., 2001; Wang et al., 2004). From 16.5 to 10.6 ka, the Moaning Cave stalagmite proxies record drier and possibly warmer conditions, signified by elevated  $d^{18}\text{O}$ ,  $d^{13}\text{C}$ , [Mg], [Sr], and [Ba] and more radiogenic  $^{87}\text{Sr}/^{86}\text{Sr}$ , during Northern Hemisphere warm periods (Bølling, early and late Allerød) and wetter and possibly colder condi-

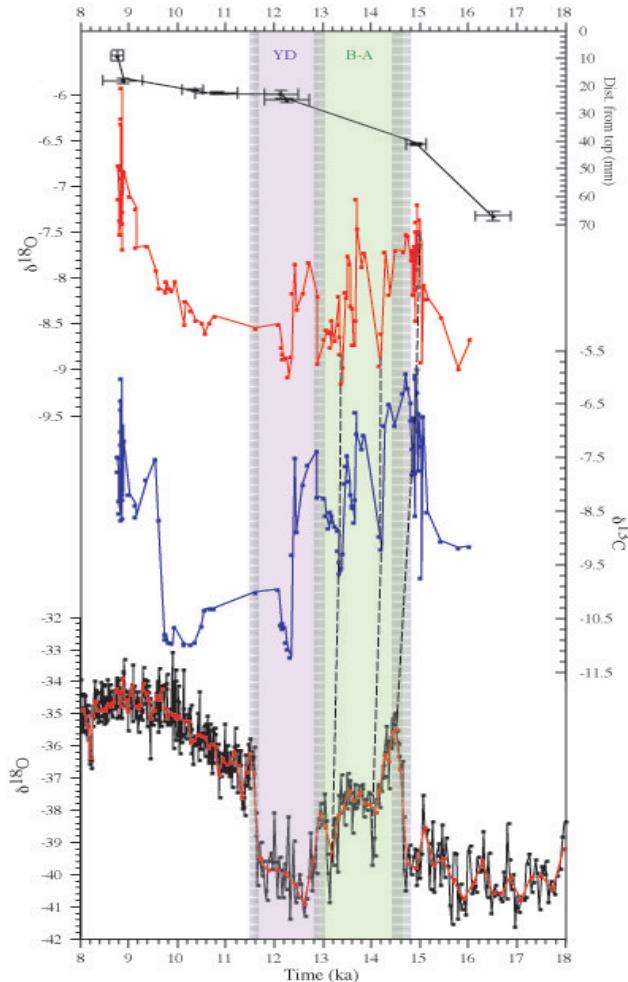


Fig. 1 Comparison of Moaning Cave  $\delta^{18}\text{O}$  (top) and  $\delta^{13}\text{C}$  with GISP2  $\delta^{18}\text{O}$  (Stuiver and Grootes, 2000). Red line is 5pt running mean of GISP2 data. Bølling-Allerød and Younger Dryas intervals in GISP2 record are shaded, respectively, green and purple. Widths of gray bars indicate uncertainties in the GISP2 age model. Black boxes show U-series ages and errors ( $2\sigma$ ) of Moaning Cave samples. Black dashed lines tie the onset of the Bølling, the Older Dryas, and the Inter-Allerød Cold Period intervals in both records.  $\delta^{18}\text{O}$  values have been corrected for changes in seawater  $\delta^{18}\text{O}$  with sea level

tions during Northern Hemisphere cool periods (Older Dryas, Inter-Allerød Cold Period, and Younger Dryas). Moaning Cave stable isotope records document a dramatic shift to wetter conditions at the onset of the Younger Dryas cold event (~12.8 ka) that persist well beyond the end of the event in the high northern latitudes (11.5 ka). This suggests that the effects of the Younger Dryas event may have been longer lived in the western Sierra Nevada than in Greenland. However, a shifting drip center and corresponding change in seepage water routing may have influenced the trace element records between 10.6 and 9.6 ka. Linkages between northern high-latitude climate and precipitation in the Sierra Nevada suggested here could indicate that, under conditions of continued global warming, this drought-prone region may experience a reduction in Pacific-sourced moisture.

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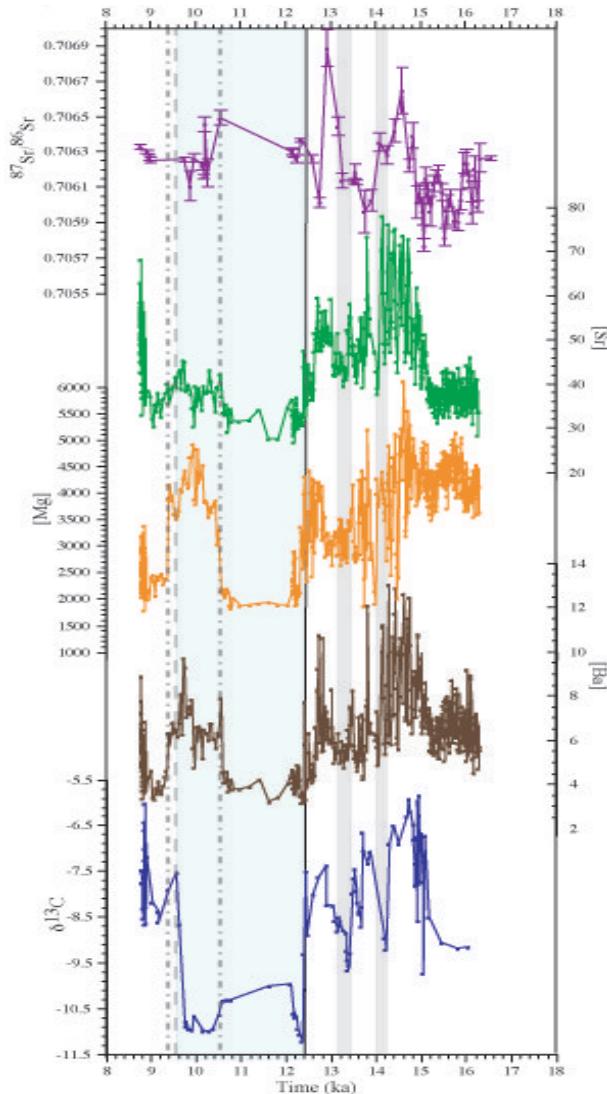


Fig 2 Comparison of Moaning Cave  $^{87}\text{Sr}/^{86}\text{Sr}$ , [Sr], [Mg], [Ba], and  $\delta^{13}\text{C}$ . Onset of the B-A (15 ka) and YD (12.5 ka) in the Moaning Cave  $\delta^{13}\text{C}$  record are indicated by solid lines. Blue bar indicates the extent of wet conditions above Moaning Cave as shown by the  $\delta^{13}\text{C}$  record. The end of YD conditions at Moaning Cave at 9.6 ka is shown with a dashed line. Thin gray bars highlight the Older Dryas, and the Inter-Allerød Cold Period intervals. Dash-dotted lines demarcate the interval of potential hydrologic variability between 10.6 and 9.6 ka as indicated by the trace element records. Increases in  $\delta^{13}\text{C}$  suggest either decreased soil respiration or increased prior calcite precipitation. Increases in [Mg], [Sr], and [Ba] also suggest increased prior calcite precipitation. Increased  $^{87}\text{Sr}/^{86}\text{Sr}$  suggests elevated water rock interactions.

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# The proglacial lakes of Mill Creek Valley, Central Indiana: Insights on ice margin maximums and implications for glacially modulated speleogenesis

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Cave Research Foundation Grant Recipient Report

The extent of Wisconsinan and Illinoian glaciations in the Midwest are defined principally by the distribution of tills and associated moraines (Willman and Frye, 1970; Johnson, 1986). Mill Creek Valley in Central Indiana is at a pivotal geomorphic intersection of glacial and karst terrains where hanging karst springs, mid-drainage waterfalls and deeply incised, underfit stream valleys reflect a complex glacial history. Prior investigations in the Mill Creek Valley show proglacial lake sediments intercalate with tills, eolian silts, and paleosols that record the advance and retreat of late Quaternary ice sheets (Autio, 1990). The Cave Research Foundation in 2008 provided funds to investigate the sedimentary and geomorphic record of proglacial lakes that formed in karst terrain near the southern limit of the Laurentide ice sheet in Central Indiana. In turn, the inferred hydrologic changes with glacial and non-glacial conditions are reflected in regional speleogenesis.

A critical discovery is the presence of proglacial lake sediments within the mouth of Porter Cave. Porter Cave located within the northern Mitchell Plain is positioned well above any slack water deposits of nearby Butler Creek or the White River (Gray, 1971). Lacustrine sedimentation in this cave is associated with ice sheet expansion, damming of Mill Creek and lake impoundment against Devore Ridge to flood caves and incise the many underfit drainages (Fig. 1). Porter Cave siphoned water and associated suspended sediments from this proglacial lake into the cave (Fig. 1b). Sediment exposures common to Porter Cave are located on shelves and within alcoves 0.5 m to 5 m above the current cave stream level. These sediments are amenable to

optical dating and contain wood fragments suitable for radiocarbon dating.

## *Significance of Research*

Optical and radiocarbon ages obtained from the cave (Fig. 2) indicate proglacial lakes flooded the cave twice, ca. 40-30 ka and 27-18 ka, associated with expansion of the Wisconsinan Laurentide ice sheet into central Indiana. The distribution of lake sediments and associated outlets indicates that the ice sheet margin in Indiana ca. 35 ka was similar in extent to the last glacial maximum. The Porter Cave chronology is consistent with other proxies of ice sheet presence, such as Midwest loess deposition, and increased meltwater flux into the Gulf of Mexico (Wood, 2009).

The 5+ m high passages of Porter Cave were sculpted by fluvial and solutional processes and predate the deposition of sediment. The timing of cave fills indicates speleogenesis appears to be retarded during glacials, consistent with the hypothesis that glacial conditions inhibit cave formation because of near total infilling of cave passages with glacio-fluvial and glacio-lacustrine sediments (Palmer, 1969; Granger et al., 2001). During glacials speleogenesis can be further retarded because meltwater can be solutionally ineffective if the source glacier overrides limestone bedrock, such as karst (Bini et al., 1996). However, proximal to the glacial margin, calcite saturated meltwater can mix with non-glacial sources potentially enhancing calcite dissolution (Ford and Williams, 2007, p 45-49), and this process has been proposed for the formation of some subglacial caves (Ford and Williams, 2007, p. 411).

This area of central Indiana experienced a nearly 50 m drop in base level with deglaciation

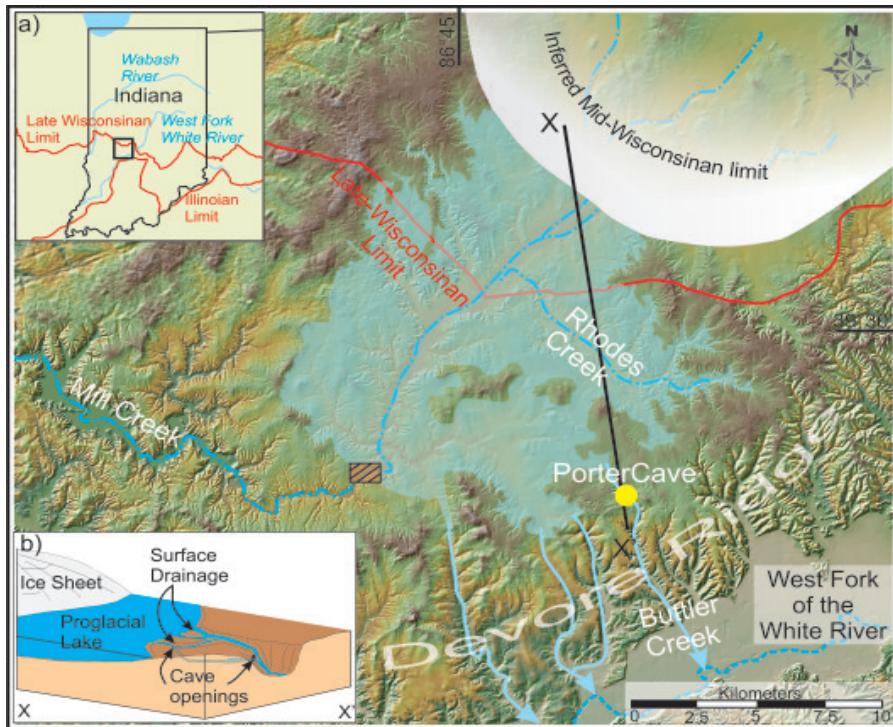


Figure 1 A middle Wisconsinan proglacial lake, ca. 40 to 30 ka and associated with ice sheet advance into the Mill Creek Valley. Depicted is the inferred minimum ice margin configuration to impound meltwater between the ice margin, Devore Ridge and inferred pre-Wisconsinan valley fill (hashed area). A subsequent late Wisconsinan proglacial lake, Lake Alaska (Autio, 1999) may have had a similar configuration to the middle Wisconsinan proglacial lake. 1A – Location of study area in the Midwest (black box). 1B – Diagrammatic cross-section (X-X') showing the relationship between Porter Cave

and draining of the proglacial lake at the end of the Wisconsinan. This “epic” hydrologic drop is likely responsible for heightened mechanical erosion that excavated formerly sediment filled passages like Porter Cave. After exhumation, the cave stream entrenched 0.5 m of the cave’s bedrock floor, and this renewed speleogenesis is the result of both mechanical and solutional processes. The passage morphology, generally 2-5 m high, may reflect multiple episodes of solutional and mechanical weathering (cf. Burger, 2004), enhanced upon deglaciation with large changes in base level. This hypothesized episodic speleogenesis of the Northern Mitchell Plain is further supported by the presences of Illinoian and pre-Illinoian proglacial lake deposits within the Mill Creek Valley (Hall and Anderson, 2001; Wood et al., in press).

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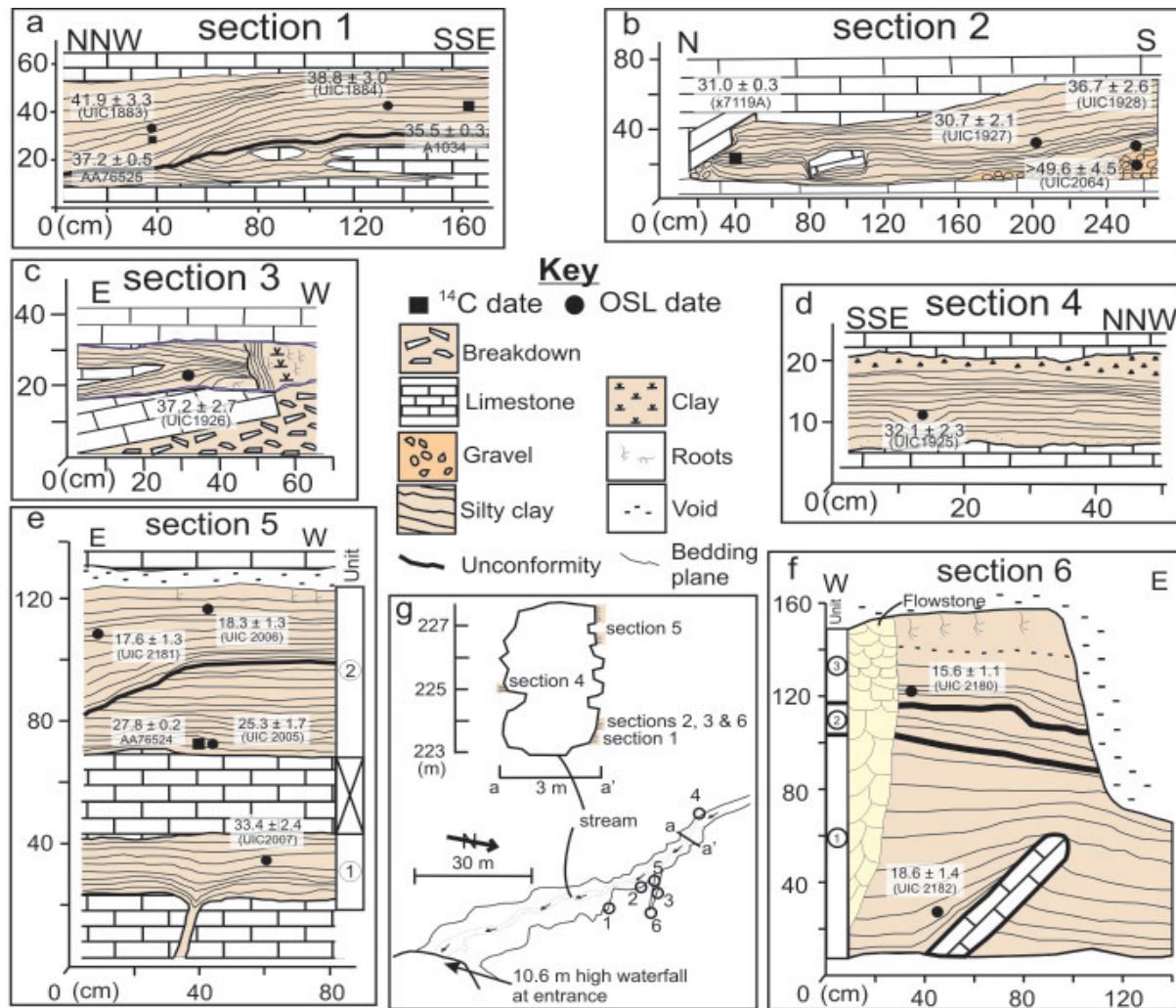


Figure 2 Sediment sections (A through F) found in the mouth of Porter Cave and associated optical and radiocarbon ages. 2E – Detail of Porter Cave indicating the locations of the sections upstream from the waterfall entrance. Idealized cross-section shows the vertical relationship of the different sections.

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# Life Sciences



# A Holocene Pollen Record Recovered From a Guano Deposit: Round Spring Cavern, Missouri

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## Purpose of Study

The purpose of this research was to determine if pollen preserved in cave bat guano can be used to produce reliable, historical records of vegetation and environmental change. Though a handful of pollen studies have been conducted on modern guano samples, to date no study has been conducted on pollen in ancient guano. Our research will attempt to determine how suitable of a tool pollen in bat guano is for reconstructing past environments, and also explores the possibility that pollen in bat guano may be a way to track or reconstruct bat behavior over time.

## Study Area at Bat Hill

We began our study at Round Spring Cavern on September 26, 2008. We selected Round Spring Cavern upon learning that it contained a number of older guano piles, especially a large, relatively undisturbed pile of guano at Bat Hill (Figure 1). The size of the guano pile indicated that a large colony of bats had once roosted at Bat Hill. Previous studies described Round Spring Cavern as a past primary maternity colony for gray bats and estimated it to have supported a population of 15,000 gray bats. These studies also suggested that the guano pile may have been about 6,000 years old but no reference was given for the date. Therefore, it was necessary that we date the pile, as reliable time control is critical to our pollen record.

## Methods

The back half of the guano pile on Bat Hill had previously been removed (at the time the walkways were established throughout the cave), leaving an exposed face that bisected the

pile. We further removed a few centimeters of guano along the face, to expose a wall of clean, undisturbed guano. We then removed small samples from the guano pile every 2.5 cm, which resulted in 38 samples in total. Though the height of the pile was approximately 100 cm, we discovered a large layer of rock embedded in the pile, probably a result of a ceiling collapse. Each sample was removed and placed into a Ziploc bag for transport back to our lab at the University of Southern Mississippi.

At our lab, we carefully extracted a small amount of guano from 4 of our samples to be sent off for radiocarbon dating (sent to Beta Analytic, Inc.). The remainder of the material was processed for pollen using a series of chemicals to break down and remove everything in the guano except the pollen. Afterward, the pollen was analyzed and counted under a microscope using established procedures.



Figure 1. Bat guano pile at Bat Hill

## Results

### Radiocarbon Dating

The results of the radiocarbon dating (Table 1) show that the guano pile is approximately 8,100 years old, much older than it was previously thought to be. These radiocarbon dating results suggest that existing previous bat population estimates at Round Spring Cave (15,000 bats) are probably too high. Our radiocarbon dates also show that the ceiling collapse event occurred roughly 2,100 years ago. After this event, the bats abandoned this roost for close to 700 years before returning about 1,400 years ago when radiocarbon dating shows that guano began accumulating again. Based off of a radiocarbon date obtained near the top of the guano pile, it is thought that the bats permanently abandoned the roost about 500 years before present day, or around 1500 AD.

### Pollen

Some interesting findings (Figure 2) have come out of this research about the possibility of using pollen in guano for studying past environments and/or bats. We did not expect to find as much pollen as we did per sample, which suggests that insectivorous bats are very efficient transporters of pollen. After the pollen is dispersed from the plants, the bats likely picked it

up on their fur while foraging. The bats then carry the pollen with them to the roost, where they ingested the pollen while grooming. This pollen is unaffected while it passes through the bats' digestive system and is eventually deposited in the guano pile below.

The amount of pollen per sample often exceeded 100,000 grains per cubic cm, which rivals pollen concentrations that one might find in a cypress swamp in Louisiana. This was certainly enough pollen to produce a reliable count, and bodes well for future studies. The pollen in the pile was also very well preserved, and allowed us to identify the different pollen types with minimal difficulty. In doing so, we found that oak and pine pollen were most dominant throughout the entire historical record, followed by hickory, which is representative of today's oak, hickory, and pine forest (Figure 3). Other notable pollen types were from the mulberry family, ash, wild grape, poplar, eastern red cedar, and elm (Figure 3).

After obtaining our results, we compared the guano pollen record to other historical pollen records from southern Missouri. These pollen records were from Buttonbush Bog, a swamp located 40 kilometers south of Round Spring Cavern and Cupola Pond, an ancient sinkhole pond located roughly 65 kilometers southeast of

Table 1

Results of AMS radiocarbon dating from Beta Analytic, Inc.

Sample	Depth (cm)	Calibrated AMS Date
Beta-254612	5 to 7.5	$620 \pm 40$ yr BP
Beta-250463	42 to 42.5	$1410 \pm 40$ yr BP
Beta-250462	47.5 to 48	$2150 \pm 40$ yr BP
Beta-250461	84 to 85	$8155 \pm 50$ yr BP

Round Spring Cavern. While the Round Spring Cavern guano pollen record was radiocarbon dated within the age range of these two lake sediment pollen records, upon comparison there appeared to be no match between them (Cupola Pond is shown in Figure 3). Explanations for this disparity are likely:

1. that the pollen archived in the guano only represents extremely localized pollen that is only within the foraging range of the bats. The foraging range for six potential species of bats (that could have inhabited Round Spring Cave) varies from 1 to approximately 15 km.
2. that different species of bats, with different foraging patterns, ranges, and behavior contributed to the pile simultaneously or at different times throughout the pile's history. The behavior of the bats, and the environment that they use to forage, will directly affect the pollen assemblage that they collect. Therefore understanding which species of bat (and their foraging characteristics) we are dealing with is critical to the interpretation of the pollen record.
3. that the guano accumulation was irregular and significant periods of time are missing or poorly represented. Though our four radiocarbon dates were in sequence, there are large portions of the pile where we are left to assume a constant sedimentation rate, which is most likely incorrect.

### *Implications*

This research shows that there is potential for pollen in guano piles to be used for the study of past environments or possibly even bats. However, further work needs to determine why the pollen record from the guano pile does not match pollen records of the Ozarks environment.

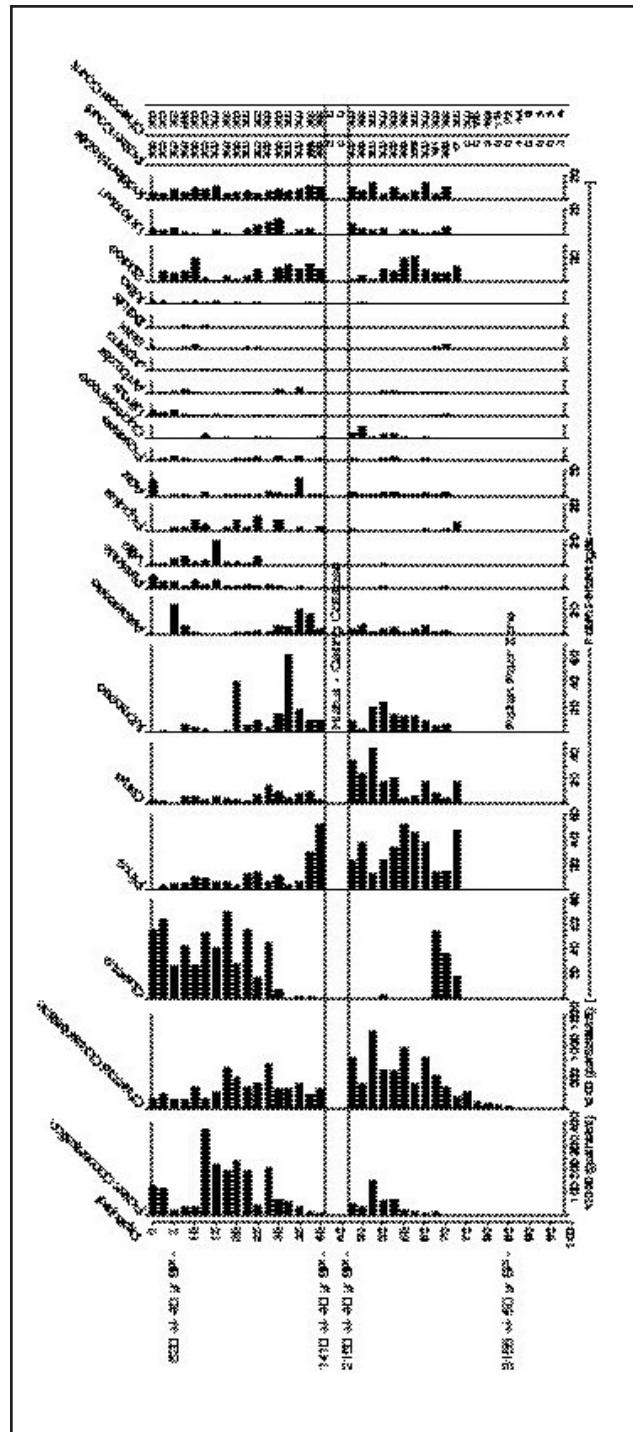


Figure 2: Pollen Percentage Diagram from Round Spring Cavern

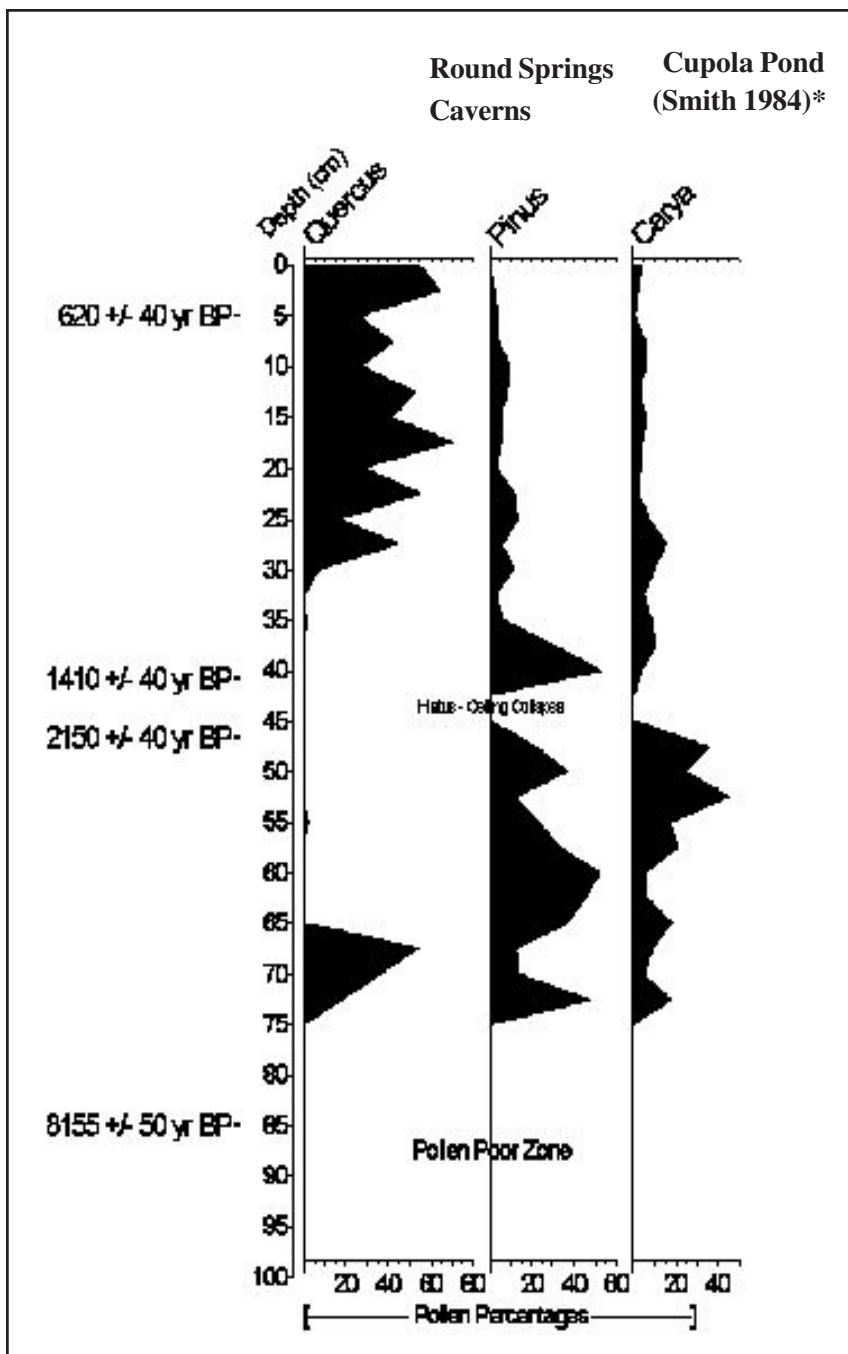


Figure 3 Comparison of the major pollen taxa from the guano pile in Round Spring Caverns and a lake sediment core taken from Cupola Pond, Missouri.

Several other findings have been made as well. The guano pile is approximately 8,100 years old and bats have left the roost in the past, in response to a ceiling collapse event which occurred roughly 2,100 years ago. Bats returned to the roost around 1,400 years ago and abandoned it again around 506 years ago, or approximately 1500 AD.

\*\*Smith, E.N., Jr. 1984. Late-Quaternary vegetational history at Cupola Pond, Ozark National Scenic Riverways, southeastern Missouri. M.S. Thesis, Department of Geological Sciences, The University of Tennessee, Knoxville, TN.

## Mineral Weathering of Lava Tubes: Iron-Oxidizing Bacteria and the Search for Life on Mars

Amy Smith and Radu Popa  
Cave Research Foundation Grant Recipient Report

Our project involves exploring ice lava tube ecosystems on Earth that are homologous to lava tube environment on Mars for the purpose of describing the native microbial communities and determining their impact on the weathering of iron minerals in the caves. Potential biosignatures such as microbial weathering features in volcanic minerals are key to the search for evidence of past and present life on Mars. Due to the large amount of iron and olivine on Mars, the presence of ice, evidence of liquid water, and the fact that subsurface life would be sheltered from temperature extremes and ultraviolet radiation, psychrophilic (cold-loving) endolithic iron oxidizers would be likely homologs for life there. Furthermore, weathering features could persist in the geologic record for billions of years depending on the natural weathering conditions, so they could be detected long after the microbes that formed them were gone.

We collected rock and ice samples from four lava tubes in eastern Oregon that are reported to have ice year-round (Arnold Ice Cave, Surveyor's Ice Cave, Edison Ice Cave, and South Ice Cave). Arnold Ice Cave is now completely clogged with ice, and South Ice Cave was most homologous with Martian cave environments (Table 1). South Ice Cave contained an abundance

of clean (no visible organic matter) basalt and ice, indicating we would likely find chemotrophs such as iron oxidizers. We also found multiple types of microbial biofilms on the walls and ceilings in South Ice Cave, including what appeared to be iridescent colonies of the common cave inhabitants *Actinomycetes* and iron-manganese nodules (Fig. 1).

We enriched for iron chemotrophic bacteria from South Ice Cave and Arnold Ice Cave by inoculating iron growth media with rock-ice from the caves. The enrichment cultures were subsequently isolated on R2A low-organic plates to obtain pure cultures. All samples and cultures were incubated between 0pC and 4pC to assure the isolates were cold-loving (psychrophilic) bacteria. The different microbes were identified by DNA sequencing of 16S rRNA genes (Fig. 2).

We also directly compared the types and diversity of isolates from Arnold Ice Cave and South Ice Cave. The South Ice Cave isolates were less diverse overall than those isolated from Arnold Ice Cave. A phylogenetic tree was constructed from a partial coding sequence of the 16S rRNA gene for all isolates and their closest known genetic match in the microbial sequence database using the nucleotide BLAST function (Fig. 3).

Sample	Depth (cm)	Calibrated AMS Date
Beta-254612	5 to 7.5	$620 \pm 40$ yr BP
Beta-250463	42 to 42.5	$1410 \pm 40$ yr BP
Beta-250462	47.5 to 48	$2150 \pm 40$ yr BP
Beta-250461	84 to 85	$8155 \pm 50$ yr BP

Table 1. Sample parameters for Arnold and South Ice Caves.



Figure 1A



Figure 1B



Figure 1C

### Conclusions

We found no significant difference in the variety of bacteria that were isolated between two ice lava caves in Oregon (South Ice Cave and Arnold Ice Cave), despite the varying environmental conditions. Many of the isolates are most closely related to known psychrophiles from Polar Regions and high altitude mountainous areas. We also found that there are slight differences in diversity between the two caves using the same culture methods for iron-oxidizing bacteria, although that is most likely due to sample location and other available energy sources.

Figure 1 A) Ice-covered basalt with iron oxides in Edison Ice Cave (OR); B) Collecting a sample from an ice fall in South Ice Cave (OR); C) Stairwell of Arnold Ice Cave submerged in ice at the entrance to the cave.

### Future directions

All isolates will be confirmed for iron oxidation/reduction capabilities, and will be incubated on olivine sand in the laboratory for future petrographic thin section analysis. Microweathering patterns formed on the olivine due to the presence of the microbes will be cataloged and compared with controls and samples produced in a Mars environmental simulation chamber. Finally, the contribution of iron-oxidizing bacteria to the weathering of basalts in lava caves will be determined based on the findings from this experiment, and the potential of the bacteria to serve as analogs to life in Martian rocks will be assessed.

Special thanks to Gus Frederick of the National Speleological Society for his help with cave information and cave location. We would also like to thank Dr. Martin Fisk and Jane Boone for their help with fieldwork.

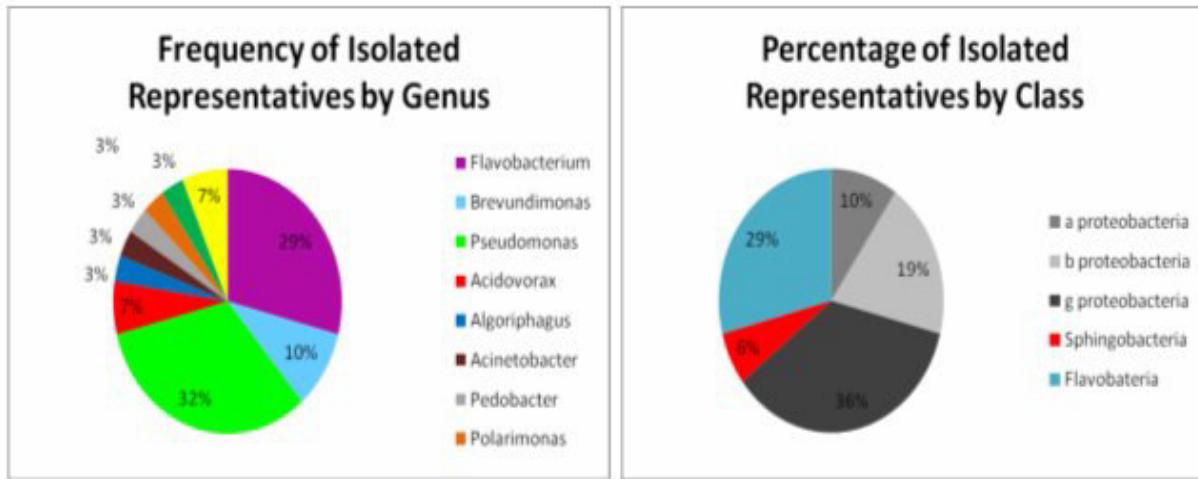


Figure 2 The frequency of isolates separated by genus. Organisms from the genera *Flavobacterium* and *Pseudomonas* were the most common bacteria isolated from the iron enrichment tubes. Right: Frequency of isolates by bacterial group. *Gamma proteobacteria* and *Flavobacteria* were the most abundant classes of bacteria in the iron cultures.

Left:

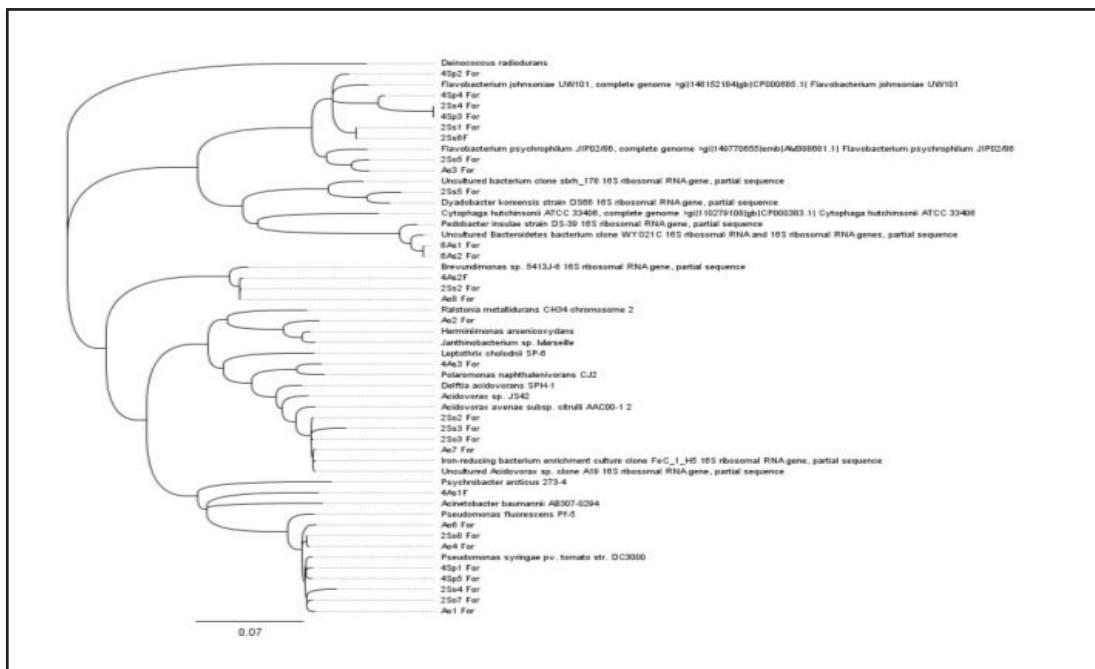


Figure 3. Phylogenetic tree of all iron media isolates and their closest known relatives by nucleotide BLAST of partial coding sequence of the bacterial 16S rRNA gene.

## Linking Habitat Disturbance to Hybridization between Surface and Cave-Adapted Salamanders

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Cave Research Foundation Grant Recipient Report

Over 95% of subterranean fauna in North America are considered vulnerable or imperiled due, in large part, to habitat degradation and restricted geographic ranges. Habitat degradation disrupts ecological barriers enabling related epigean organisms to invade and either outcompete or temporarily replace cave-dwelling taxa. However, another potential outcome is genetic introgression and, ultimately, genetic swamping of subterranean forms. Although the threats of introgression and genetic swamping of rare species by common congeners have been investigated and are seen as increasing among related epigean species, these threats to subterranean taxa have received little attention. Few studies have addressed the threat of introgression and genetic swamping of subterranean taxa by related epigean congeners and how habitat disturbance may facilitate this threat. Disturbance of specialized habitats, such as subterranean environments, may facilitate invasion by related epigean generalists and breakdown of reproductive isolation leading to introgression.

This project examines the relationship between habitat disturbance and the nature and extent of genetic introgression between generalists and obligate, subterranean specialists using salamanders in the genus *Gyrinophilus* as a model. Specifically, this study investigate introgression and the risk of local extinction of an endemic subterranean salamander (Berry Cave Salamander, *G. gulolineatus*) via genetic swamping of a related epigean congener (Spring Salamander, *G. porphyriticus*), and test a specific mechanism that facilitates contact and gene flow between related subterranean and epigean forms. Specifically, we address three questions: (1) Is

habitat disturbance required for generalists to exploit specialized, subterranean habitats, and, if so, does a broad-scale pattern exist; (2) When related generalists and specialists coexist, does gene flow occur, and, if so, are the nature and extent of gene flow related to habitat disturbance; and (3) What ecological factors facilitate or prevent prolonged gene flow in subterranean habitats and what are the outcomes?

### Results

(1) We have compiled a large data set of subterranean occurrences of generalists (*G. porphyriticus*) and specialists (*G. gulolineatus*, *G. palleucus*, *G. subterraneus*), part of which has been published (Miller and Niemiller 2008). We have not yet completed our analyses of habitat variation among sites, but preliminary assessment indicates (i) evidence of an association between at least one aspect of habitat disturbance (allochthonous debris flow) and *G. porphyriticus*, and (ii) potential evidence of segregation by hydrologic characteristics, with the generalist inhabiting caves with small, high gradient streams (similar to the surface streams they most commonly inhabit), and specialists inhabiting caves with larger, lower gradient streams.

Because of the paucity of autotrophs in subterranean ecosystems, trophic resources are introduced from epigean sources (e.g. bat guano and detritus). Although these resources may not limit population growth in all cave systems, they are often unevenly distributed (36) and are only exploited by organisms adapted to locating such resources in complete darkness. If habitat disturbance increases terrestrial food resources, then epigean, generalist species may establish semi-

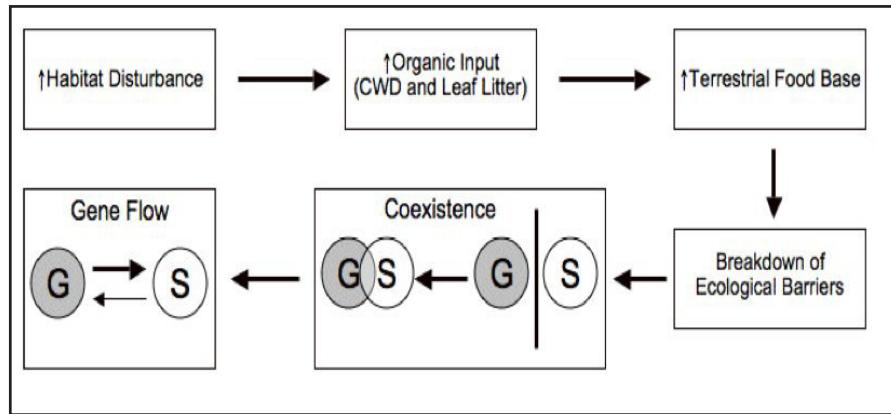


Fig. 1 Flow chart illustrating how habitat disturbance can cause between generalists (G) and specialists (S) in subterranean habitats.

permanent subterranean populations. Indeed, we have documented sizeable populations of Spring Salamanders only in cave systems with large inputs of organic matter from the surface. Predictably, cave systems with low input support small populations. When these populations are established in cave systems already inhabited by related specialists and other reproductive isolating mechanisms have not developed, the potential for gene flow exists and may result in a variety of outcomes (Fig. 1), including reinforcement of reproductive isolating mechanisms, hybrid speciation, introgression, and genetic assimilation of taxa.

We are currently investigating how increased terrestrial food availability caused by increased organic input into subterranean environments facilitates sustained contact and subsequent hybridization between Spring Salamanders and their subterranean congeners. To determine whether Spring Salamanders can meet their basic energetic requirements in subterranean environments, we are conducting experiments to determine the metabolic demands and feeding efficacy of Spring Salamanders relative to Berry Cave Salamanders. Metabolic rate and daily energy requirements are being estimated for Spring Salamanders (larvae and adults) and Berry Cave Salamanders in the laboratory with the expectation that Spring Sal-

manders will have a higher metabolic rate and, thus, greater caloric demands. To examine feeding efficacy, experiments are being conducted to estimate foraging success in terrestrial and aquatic habitats and in dark and light conditions with the expectation that metamorphosed Spring Salamanders will be unable to meet minimum food requirements in total darkness at typical cave resource levels. Finally, we are investigating feeding efficacy in the field by examining the relationship between number of lateral line neuromasts and body condition. Interestingly, larval Spring Salamanders with more lateral line neuromasts tended to have higher body fat (Fig. 3). Berry Cave Salamanders had far more neuromasts and there was no evident relationship with body fat. This data support an important idea about the adaptive value of cave-associated phenotypes. Hypertrophied lateral line systems enhance foraging efficiency in total darkness underwater.

(2) When related generalists and specialists coexist, gene flow does occur, but the ecological segregation described above appears to limit opportunities for interbreeding. The nature of the cave environment sug-

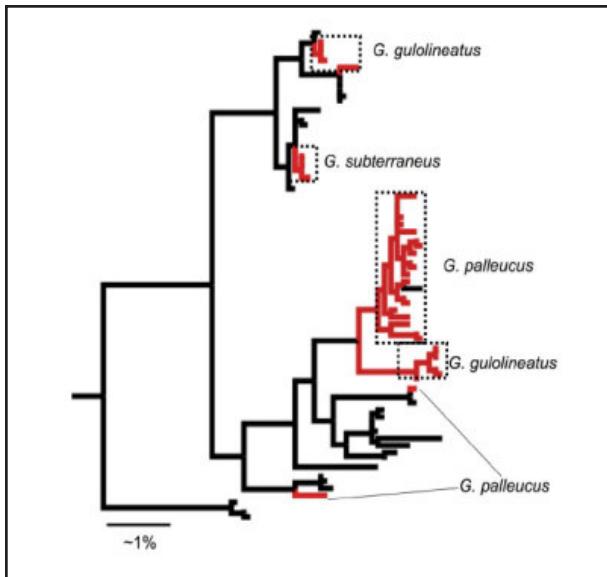


Fig. 2 MtDNA sequences from obligate cave-dwelling *Gyrinophilus* (in red) are nested within the gene tree of the troglophilic *G. porphyriticus* (in black) showing evidence of recent origin and multiple independent invasions. Data from nuclear RAG-1 are similar (Niemiller et al. 2008, 2009).

gests that hybridization between related surface and subterranean species would occur within the twilight zone. However, habitat disturbance may alter the width and slope of the gradient, possibly resulting in complete genetic swamping of the subterranean species. Using morphological and genetic analyses, we have documented hybridization between the Berry Cave Salamander and Spring Salamander at Mead Quarry Cave in Knox Co., Tennessee (Fig. 2). However, other area caves only contain one of the two species with no evidence of hybridization. Likewise, genetic evidence suggests putative hybridization between the single cave endemic West Virginia Spring Salamander (*G. subterraneus*) and Spring Salamander at General Davis Cave in Greenbrier Co., West Virginia. Both of these cave systems exhibit habitat disturbance either from previous quarrying operations (MQC) or large inputs of organic matter (GDC). However, no obvious cline was detected at either cave. Additionally, at Cruze Cave in Knox Co., Tennessee, earlier workers documented both Berry Cave Salamanders and

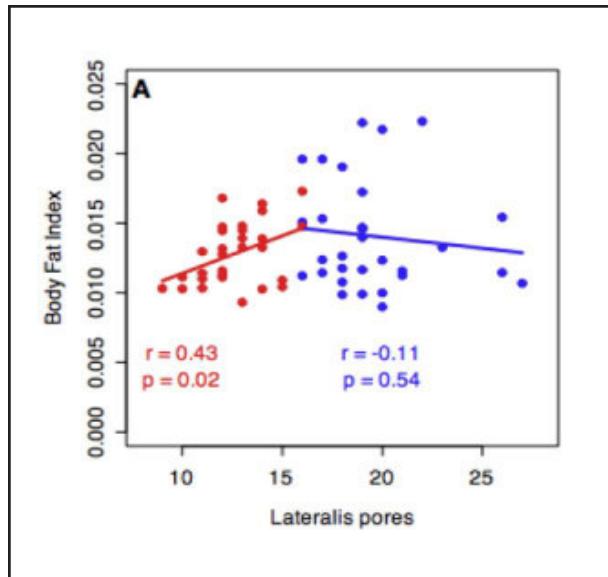


Fig. 3 Relationship between the body fat index (Vol/mass corrected for SVL and the number of lateral line neuromasts for Spring Salamanders in Cruze Cave (red) and Berry Cave Salamanders in Mead Quarry Cave (blue). Pearson correlation coefficients and *p*-values given in the corresponding colors

Spring Salamanders, but we have only observed Spring Salamanders in the last six years, implying a displacement (or at least replacement) of the cave specialist *G. gulolineatus* at that site. The site is highly disturbed, with a large volume of organic debris and trash, trematode parasites, and a highly dynamic stream channel that has changed considerably during flood events. Although our genetic data are consistent with a small amount of hybridization at Cruze Cave, we interpret the pattern there as an ecological replacement rather than genetic swamping.

(3) Based on these results, the primary ecological factor affecting gene flow between *Gyrinophilus* species appears to be “macro” habitat segregation, i.e., they tend to occur in distinct kinds of caves, limiting encounters between cave specialists and the generalist Spring Salamander. This habitat segregation is probably associated with tradeoffs between aquatic and terrestrial

feeding performance. Limited data suggest that ecological replacement of one form by the other can be rapid if habitat disturbance converts a low-resource, low stream gradient cave into a high gradient cave with high debris flow.

#### *Relevant Publications*

Niemiller ML, Osbourn MS, Fenolio DB, Pauley TK, Miller BT, and Holsinger JR. In press. Conservation Status and Habitat Use of the West Virginia Spring Salamander (*Gyrinophilus subterraneus*) and Spring Salamander (*G. porphyriticus*) in General Davis Cave, Greenbrier Co., West Virginia. *Herpetological Conservation and Biology*.

Niemiller ML, Miller BT, and Fitzpatrick BM. 2009. Systematics and evolutionary history of subterranean *Gyrinophilus* salamanders. *Proceedings of the 15th International Congress of Speleology*, Kerrville, Texas 15: 242–248.

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Miller BT, and Niemiller ML. 2008. Distribution and relative abundance of Tennessee cave salamanders (*Gyrinophilus palleucus* and *G. gulolineatus*) with an emphasis on Tennessee populations. *Herpetological Conservation and Biology* 3: 1–20.

# Foraging in the Cave Environment: The Ecology of the Cave Spider *Meta ovalis* (Araneae: Tetragnathidae)

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The orb-weaving spider *Meta ovalis* (Gertsch 1933) is an invertebrate predator commonly found throughout caves in North America. This study examined the relationship between the cave habitat, population distribution, and available prey on web construction and foraging behavior in the troglophilic orb-weaving spider, relative to the patterns of environmental variation and light gradients in caves.

During the two-year survey (2007-2009), individuals were not found to move between different caves or even between separate research sites within a single cave. Only within site dispersal was observed to occur in this species; individuals were also not found in the surface habitat surrounding cave entrances (but see Smithers 2005). Individuals that were paint-marked as residents of a particular cave site were continuously found within that site, no recaptures occurred other than at the site of original residence. Within

the confines of a single cave site, marked spiders were found occupying all three terrestrial light zones, but due to the method of marking we were unable to determine if individuals demonstrate zonal fidelity or move freely across light zones.

The size of each research site varied with the size of the cave and site entrance. Each site was divided according to the natural light zones: entrance, twilight, and dark. Although spiders were found throughout the cave, we found distinct preferences for zonal location among adult and sub-adult spiders. Adults are found most commonly in the twilight and dark zones (often found at the same location for months on end) whereas sub-adults are most common in the entrance zone, although they are present throughout the cave habitat in lower numbers (Figure 1).

Sub-adult spiders were also frequently found in collections of overlapping webs, in which the number of individuals varied slightly but was not significant across light zones. These group-

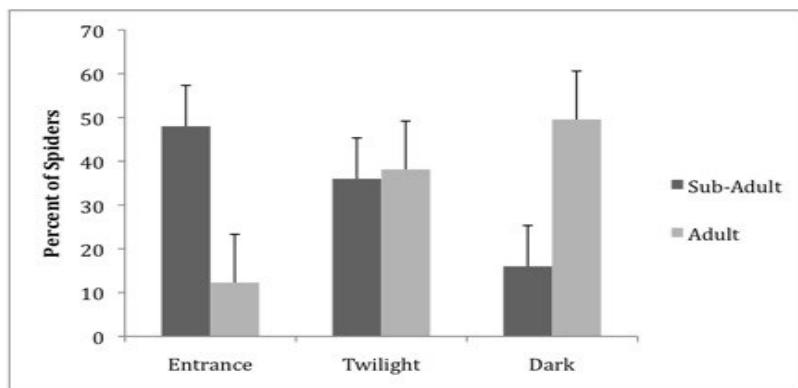


Figure 1. Percent ( $\pm$  S.E.) of sub-adult and adult spiders found in each cave light zone, across all caves

ings were most often found in the dark zone; the webs in these groups were also the most widely spaced of all grouped webs (i.e. more space between the overlapping capture areas of the webs).

While the light zones did not influence the number of individuals in grouped webs, zonal location and maturity do impact the overall web size. Adults tend to construct webs with larger hubs than those of sub-adult webs and capture areas of webs found in the entrance and twilight zone are significantly larger than those found in the dark zone (Figure 2). While not different in over all size, the capture areas of adult and sub-adult webs do differ in the number and spacing of spiral lines. Adult webs have fewer lines with significantly wider spacing than sub-adult webs. This may indicate that adult capture areas with an average spacing of 7.1mm between spiral lines are constructed of less silk fibers than sub-adult webs that have an average spacing of 4.4 mm. Spacing of the spiral lines in capture areas has

been speculated to impact the type and frequency of prey interception in orb-weavers (Backledge & Eliason 2007; Clackledge & Zevenbergen 2006; Chacon & Eberhard 1980) and therefore the foraging effort by individuals (Sherman 1994; Vener & Casas 2005). Observations of prey capture suggest that adult spiders are more likely to actively forage outside of the web, whereas sub-adult spiders are more likely to depend on the web for prey interception. Therefore the structure and location of the web becomes important in determining the likely foraging success of an individual.

The distribution of a non-obligate arthropod predator across all terrestrial zones of caves may impact multiple aspects of the cave ecosystem, as individuals will preferentially forage for the available prey types in each zone. In the twilight and dark zones of caves, this may mean more predation on other cave residents, rather than the incidental surface prey found in the entrance zone

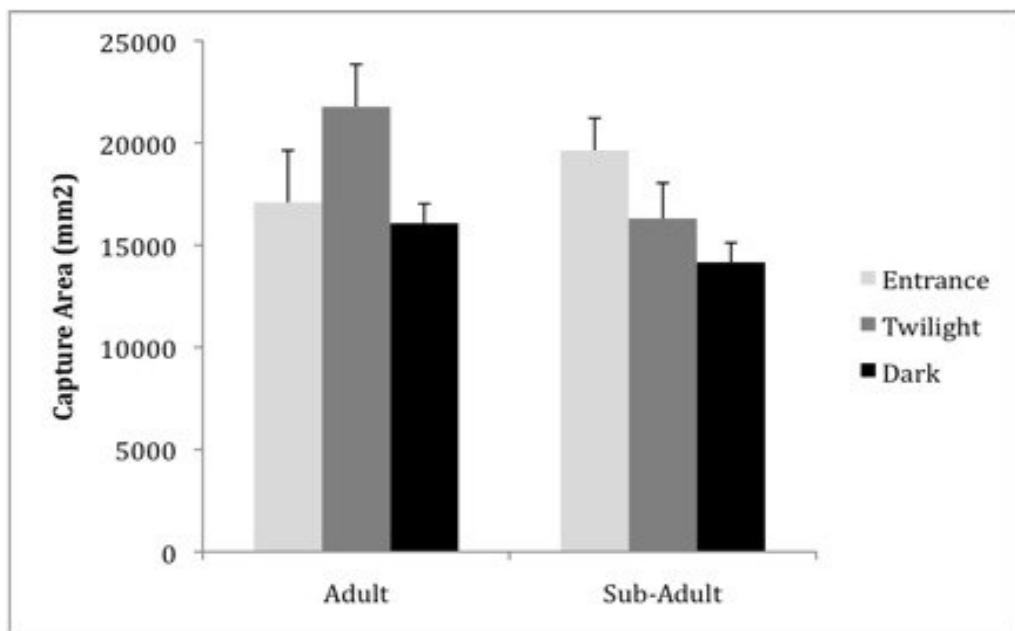


Figure 2 Mean capture areas of *Meta ovalis* orb-webs ( $\pm$  S.E.) across study sites. Capture areas of webs found in the entrance and twilight zones are significantly larger than the capture areas found in the dark zone. Maturity has no impact on capture size, and there is no interaction effect between maturity and zonal location of the web.

of caves. This predation on obligate cave dwellers and other cave residents may be important in terms of understanding community regulation and conservation of endemic species.

The Cave Research Foundation funding not only supported this research, but also provided opportunity for valuable research experience and training for 15 advanced high school and undergraduate students through the Metro Early College High School (Columbus, OH) and The Ohio State University, Department of Evolution, Ecology, and Organismal Biology. Results of this work have been submitted for publication and should be forthcoming.

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2. Rector, West, & Roberts, Foraging in a cave habitat: web structure of the orb-weaving cave spider, *Meta ovalis* (Araneae: Tetragnathidae), Journal of Arachnology (submitted).

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Venner, S. and J. Casas. 2005. Spider webs designed for rare but life-saving catches. *Proceedings of the Royal Society of London B* 272: 1587-1592.

## Onondaga Cave – bio-inventory of newly discovered passage.

*Mick Sutton and Sue Hagan*

The passage recently discovered just off a tour trail in Onondaga Cave was examined on April 24, 2008. Until its rediscovery in the fall of 2007, the passage had been sealed by an accumulation of trash and sediment. This blockage probably dates from the “cave wars” era of the 1930’s. Although blockage for human visitors does not necessarily imply biological isolation, in this instance it does seem to have been the case.

The habitat in this 100 m long passage consists of damp red clay floors and walls. There are occasional slow drip points, but no standing pools. The passage is notable for the scarcity of any wildlife, or of any obvious source of nutrition. Past habitation by bats is indicated by a fairly large scattering of skeletal remains, primarily finger bones, and a very sparse scattering of old, dry bat droppings. In addition, there were very sparse rodent droppings, some rat-sized, some mouse-sized. Some fungal mycelia were present on some droppings, but no macro-invertebrates were associated with them. The only other potential nutrition source was a small patch of possible, very degraded dung from a larger mammal. Indications of possibly more extensive dung deposits consisted of several small patches of hackberry shells, which tend to remain after the dung matrix had disappeared. There are numerous other paleological remains, in the form of skeletal material and claw marks in the clay walls and floor, but these have been the subject of a separate paleontological survey, and are beyond the scope of the present report.

The only signs of macro-invertebrate life were two dead millipedes, widely separated, and a beetle elytron (wing case). The millipedes were somewhat degraded, and clearly not recently deceased. They were white, about 8 mm long, and consisted of about 28 segments. They are therefore almost certainly the common troglobitic chordeumatid *Tingupa pallida*, a species which has been recorded from Onondaga Cave. The

beetle’s identity is more speculative, but the elytron was consistent with the common troglobitic fungus beetle *Ptomophagus cavernicola*, also known from Onondaga Cave.

One puzzling feature was a series of very fine scratch marks on the clay banks. These marks, which are up to 1 mm in depth and perhaps 0.5 mm wide, were initially interpreted as probable claw marks from bats. However, it soon became apparent that the meshwork of marks are more or less ubiquitous, covering most of the exposed vertical, sloping and overhanging clay surfaces, and forming a background to the more prominent claw marks from larger animals. Clearly, this was not compatible with the very limited bat use of the passage indicated by the skeletal and scat remains – moreover, the marks occurred on surfaces where bats would not be expected, such as under ledges with very little headroom. Careful examination showed some instances where the scratch marks graded into rillen-like features where horizontal and vertical clay surfaces met. In other instances where the clay had been disturbed, the marks seemed to be associated with very fine clay laminations. We therefore believe the fine scratch marks to be geological rather than biological in origin, although we are unable to suggest a plausible mechanism.

Now that the passage is open, it will be interesting to see whether it is recolonized by bats and other mammals, and if so how soon this results in an active detritivore-based ecosystem.

One other biological observation is worth noting – in the main passage directly above the tour trail, we observed a solitary probable small-footed bat (*Myotis leibii*). The observation should be regarded as tentative, since the bat was not handled for confirmation, but it had the typical prominent black face-mask and relatively small size of that species. Onondaga Cave is one of very few sites in Missouri where this rare bat has been recorded.

## Onondaga Cave - New Discovery

Crawford County, Missouri  
Onondaga Cave State Park  
CFD 001

Surveyors & Fiberglass Tape  
Survey By:  
Jeff Crews, Andy Free, Lyle Hutchins, Ben Miller, & Kyle Rybacki

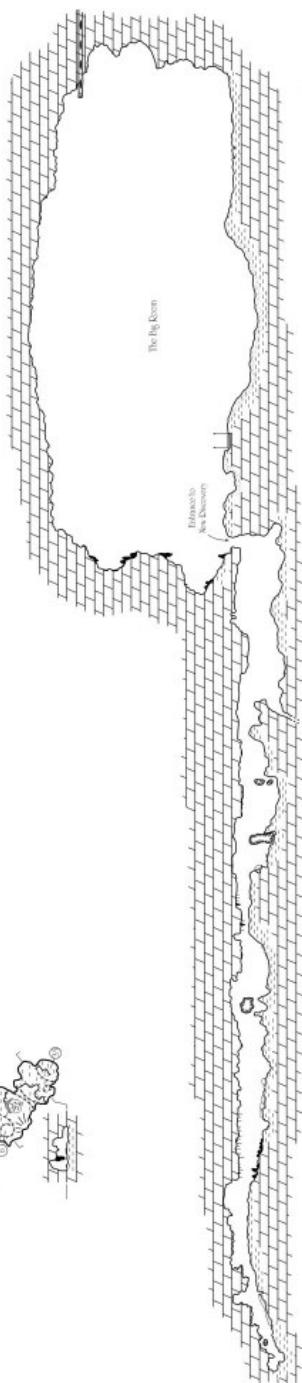
April 24, 2008

Cave Research Foundation

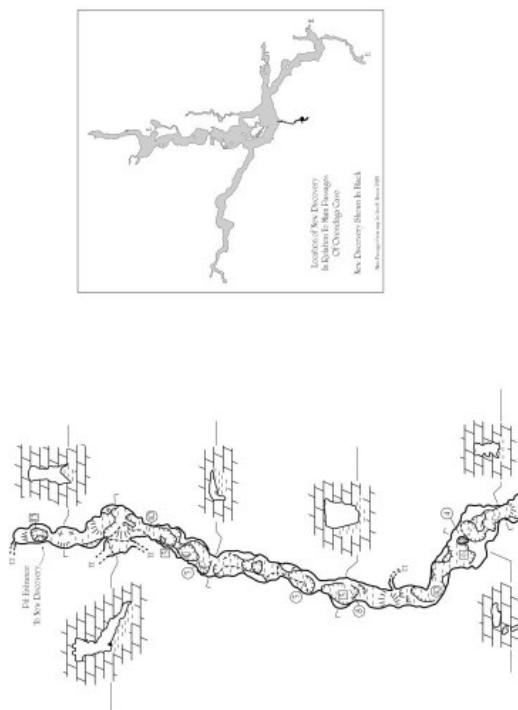
Map symbols from Missouri Speleology, Volume 31 No. 1-4 (1991)



Total Length of New Discovery: 3094 Feet, 943 Meters  
Total Length of Onondaga Cave: 9464 Feet (1783 Miles),  
2870.2 Meters (2.87 Kilometers)



Dated by Ben Miller 2008



# Cave Survey and Cartography



Joke Vansweevedt sketches in Twin Falls Cave, Lava Beds National Monument. Photo: Pat Seiser.

## **Survey, Cartography, and Cave Database work at Buffalo National River**

*Scott House*

Buffalo National River has over 350 documented caves within its borders, plus another 200 shelter caves and significant karst features. In the last two years field work has been intermittent due to logistical problems and backlog in cartography. However, considerable progress has been made during those field trips that occurred.

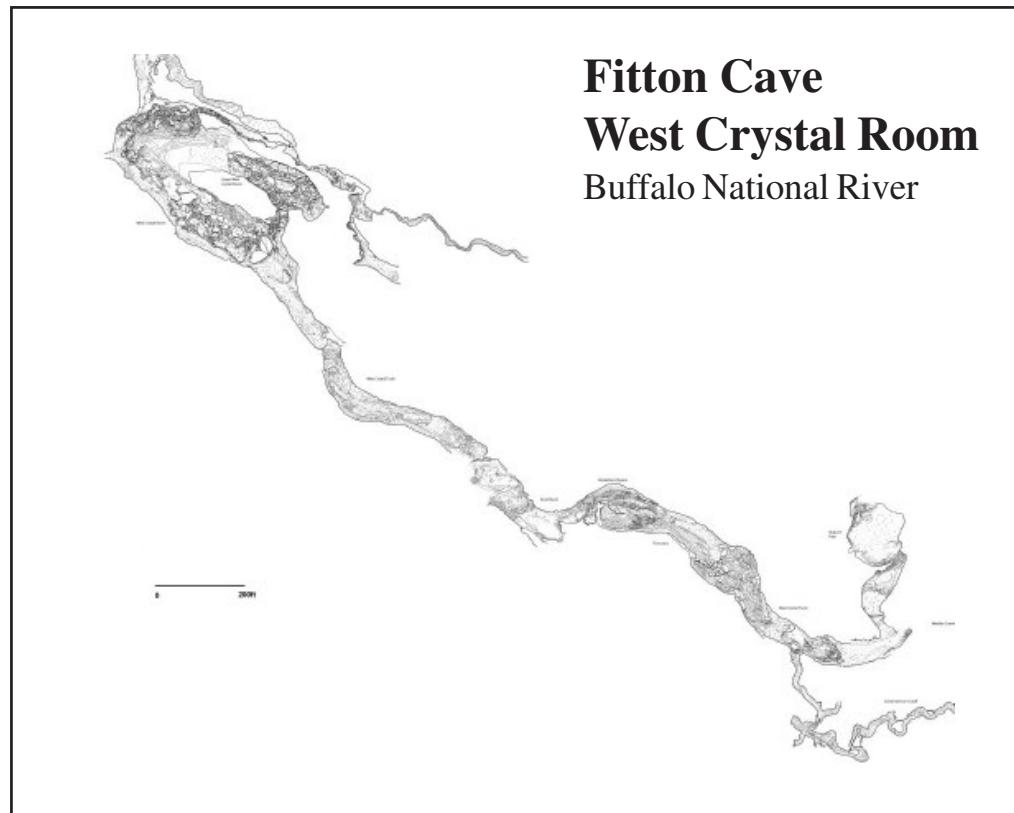
Two areas of Fitton Cave received attention. A total of five crews surveyed sections of the Bat Cave entrance and passage. Drafting of the West Crystal and Beauty Cave sheets has progressed nicely. One area off of West Crystal was surveyed.

Three small caves on George Mountain were surveyed in one day; the final maps were drafted by Scott House and Bob Taylor.

The survey of Novak Spring Cave was started several years ago but had not been completed due to washouts. Drafting on the map is now being done by Jeff Bridgman.

A new survey of Copperhead Cave was begun by Jeff Bartlett. Copperhead is a wet canyon cave, popular with visitors. Over 2000 feet have been mapped.

Through funding provided by the NPS, a new database for park caves was written by Scott House. Old data from the park was imported in to it, and the process of rectifying locations was begun with help from Chuck Bitting of the park. Locations were imported into a topographic map program and a system of qualifying the cave locations was used to establish quality control. This program is continuing with additional narrative material being added to the database.



## Ozark National Scenic Riverways Cave Survey and Cartography

Scott House

Operating out of the Powder Mill Research Center, CRF continues to coordinate and facilitate cave survey and cartography efforts in the Ozark Riverways and surrounding areas. In 2008-2009 approximately 30 caves were surveyed.

A recon crew confirmed that the map of Liberty School Cave was complete and correct, so that survey was deemed finished.

New survey was done in Branson Cave, a gated permit cave that CRF gated a few years ago; only one slimy passage remains to be surveyed in that 2500 foot-long cave. Additional survey was also done in Bluff Cave, another permit cave that CRF gated.

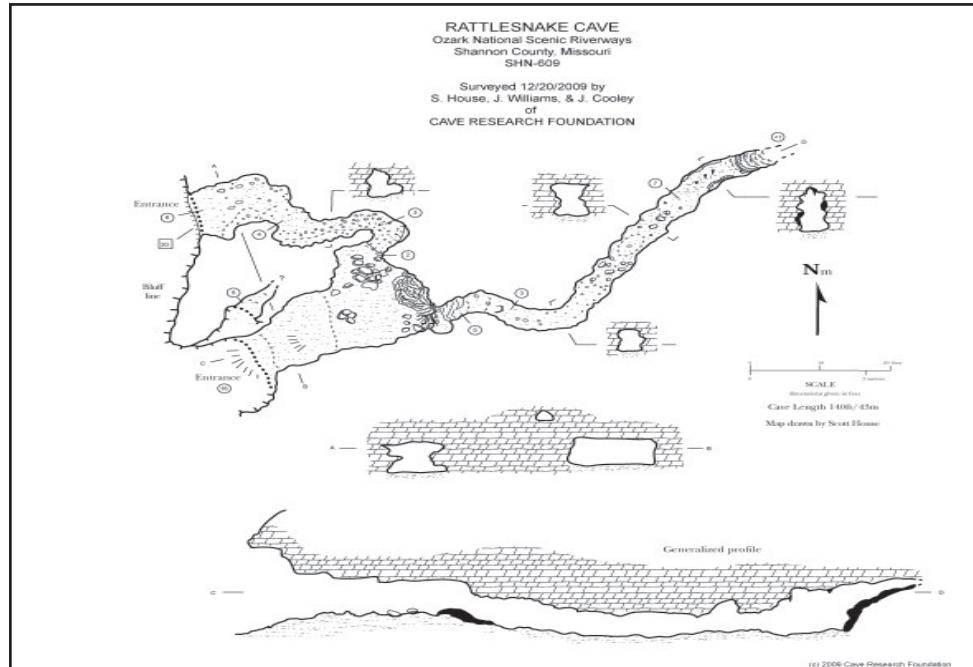
A cluster of small, but interesting, caves were surveyed in the area of Alley Spring. These caves are frequently entered by visitors at the spring. The possibility exists that we make an interpretive sign utilizing some of this information.

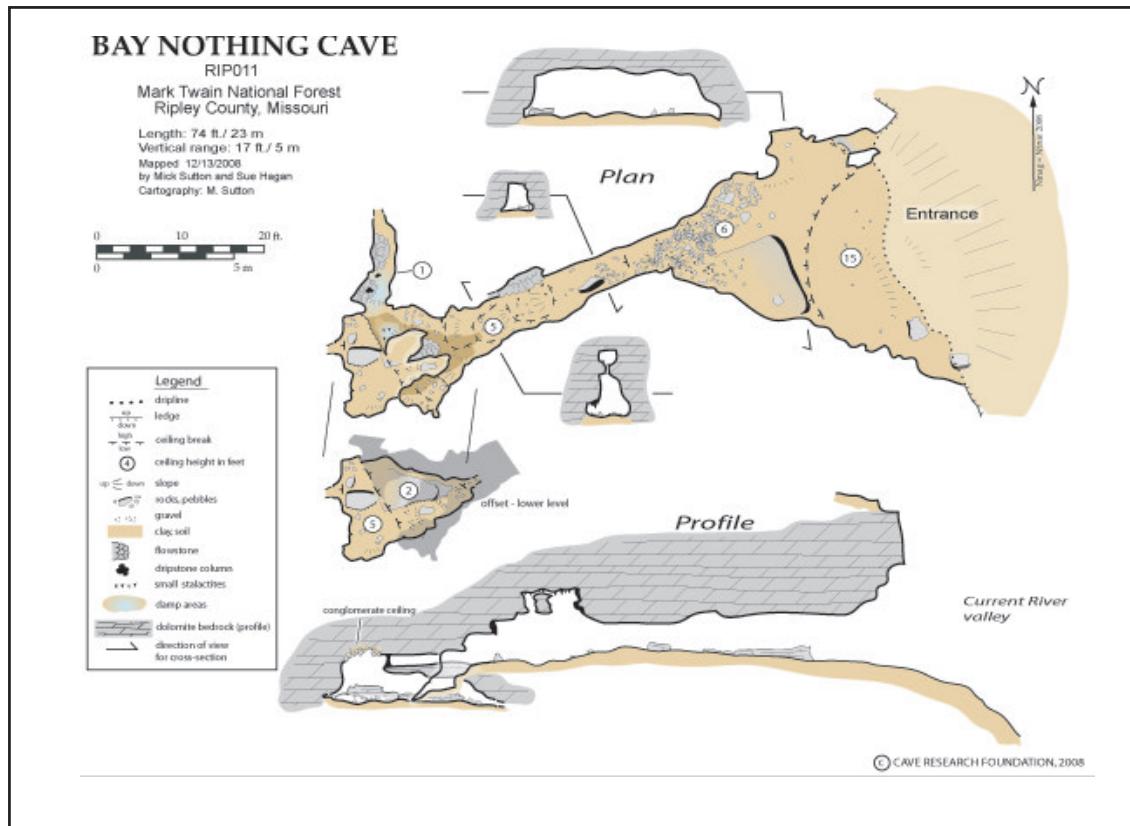
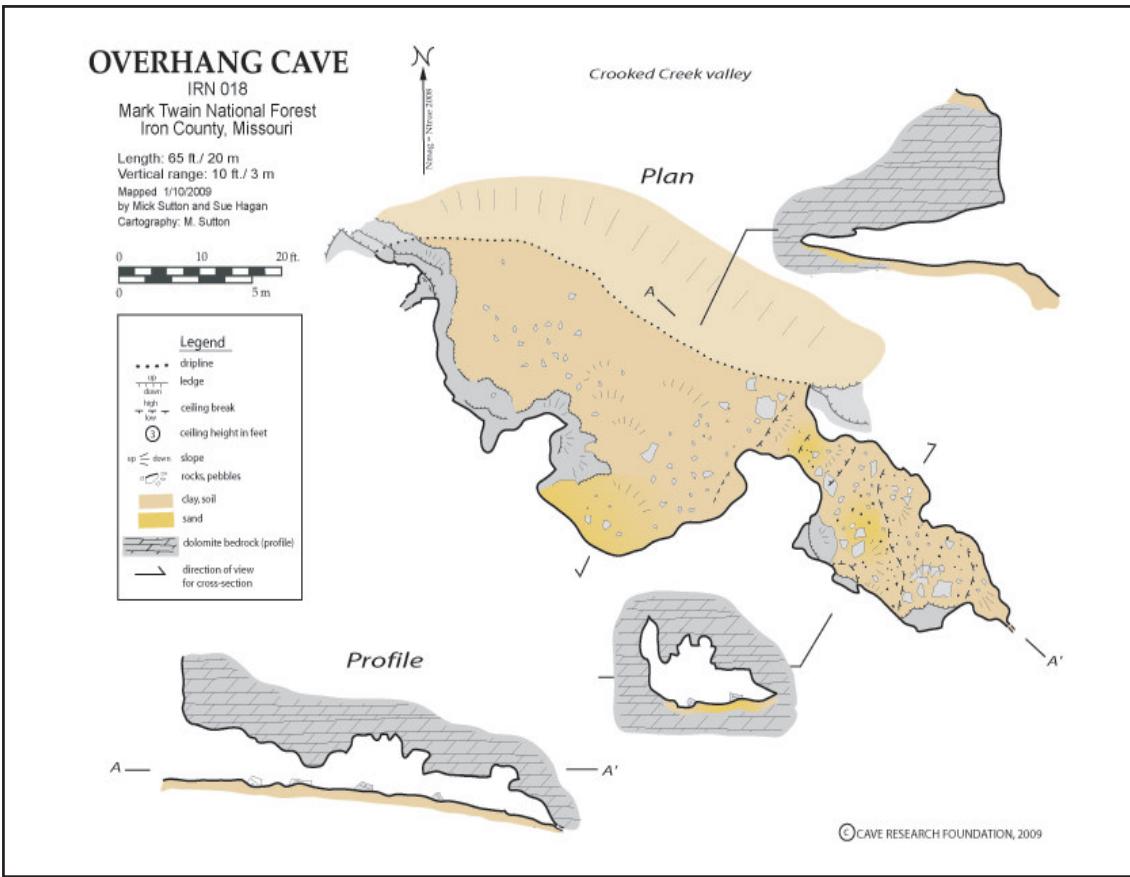
Continuing survey was done in Ditch Cave, a wet but well-decorated cave whose entrance lies in the road ditch of a state highway. A cluster of caves on the upper Current River was surveyed: these included Walter Lipps Cave, an anastomotic cave; Bealert Cave, a nicely decorated biologically-active wet cave, and several smaller ones. A survey was begun in Bealert Blowing Spring which is a new spring cave.

Two crews added additional passage to McCubbin Hollow Cave, a low but well-decorated cave that has significant biological resources. Surveys continued in nearby Sluiceway Cave, a large wet cave.

A series of nine caves were surveyed along a section of the Jacks Fork River. Most of these represented new finds and the maps have all been completed. Among the more interesting of these were Rattlesnake Cave and the two Alcove Caves.

Several other caves, small but interesting were finished in scattered areas throughout the





park. These include Spring Pipe Bluff Cave, Prairie Hollow Cave (in Precambrian rhyolite, no less); Spring Hollow Cave Spring, and others.

Drafting continues on the series of eight caves that comprise the Tunnel Bluff area in the extreme southern end of the park. Additional trips were taken to Hollow Cave, a large and significant stream cave on Missouri Department of Conservation land that lies within the park. Here,

both low level stream passages and upper level canyons have been surveyed. Other MDC caves that lie within the park and are in various stages of drafting include Powder Mill Creek Cave and the Marvel/Blair Creek Cave.

Most of the cartography work has been done by Scott House with additional caves done by Dan Lamping and Bob Osburn.



Scenes from CRF's project work in the Ozarks

## Survey, Cartography, and Cave Database work at Buffalo National River

Scott House

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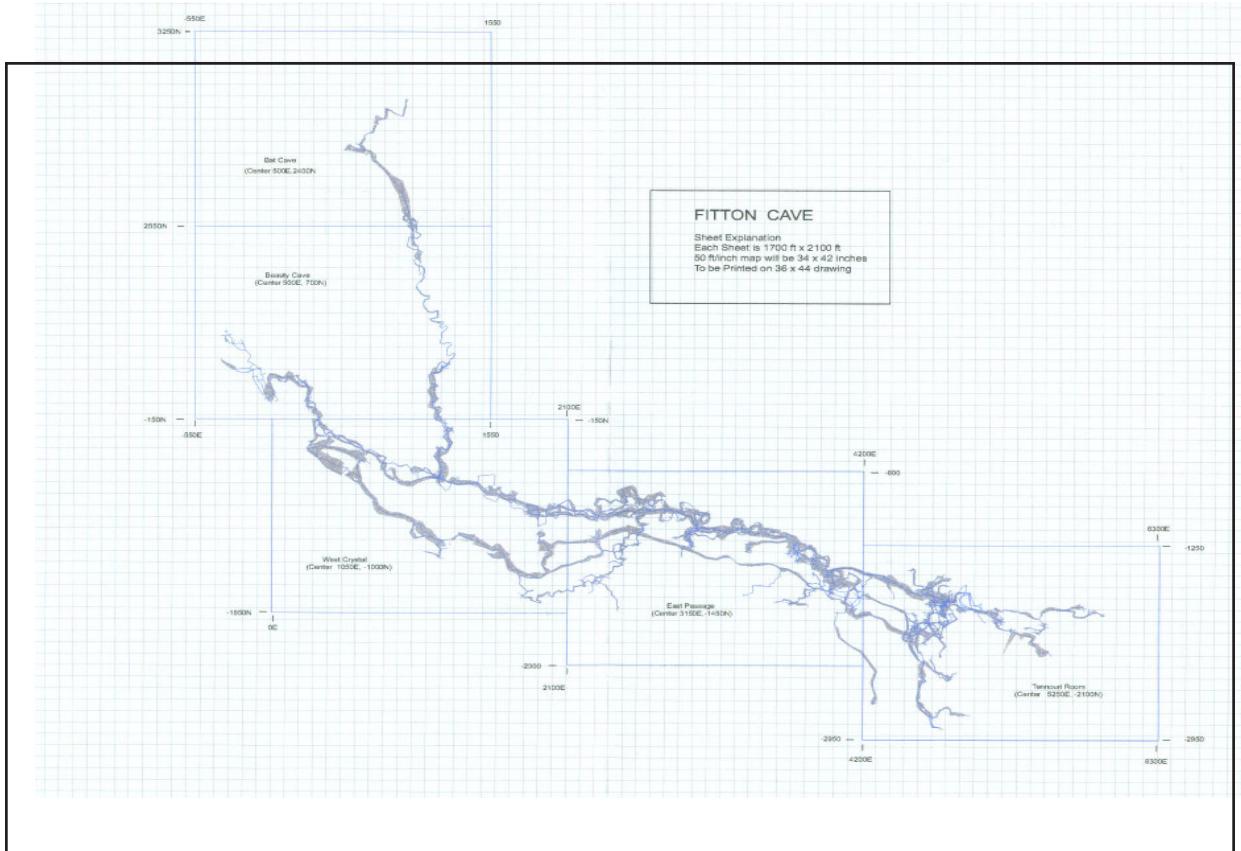
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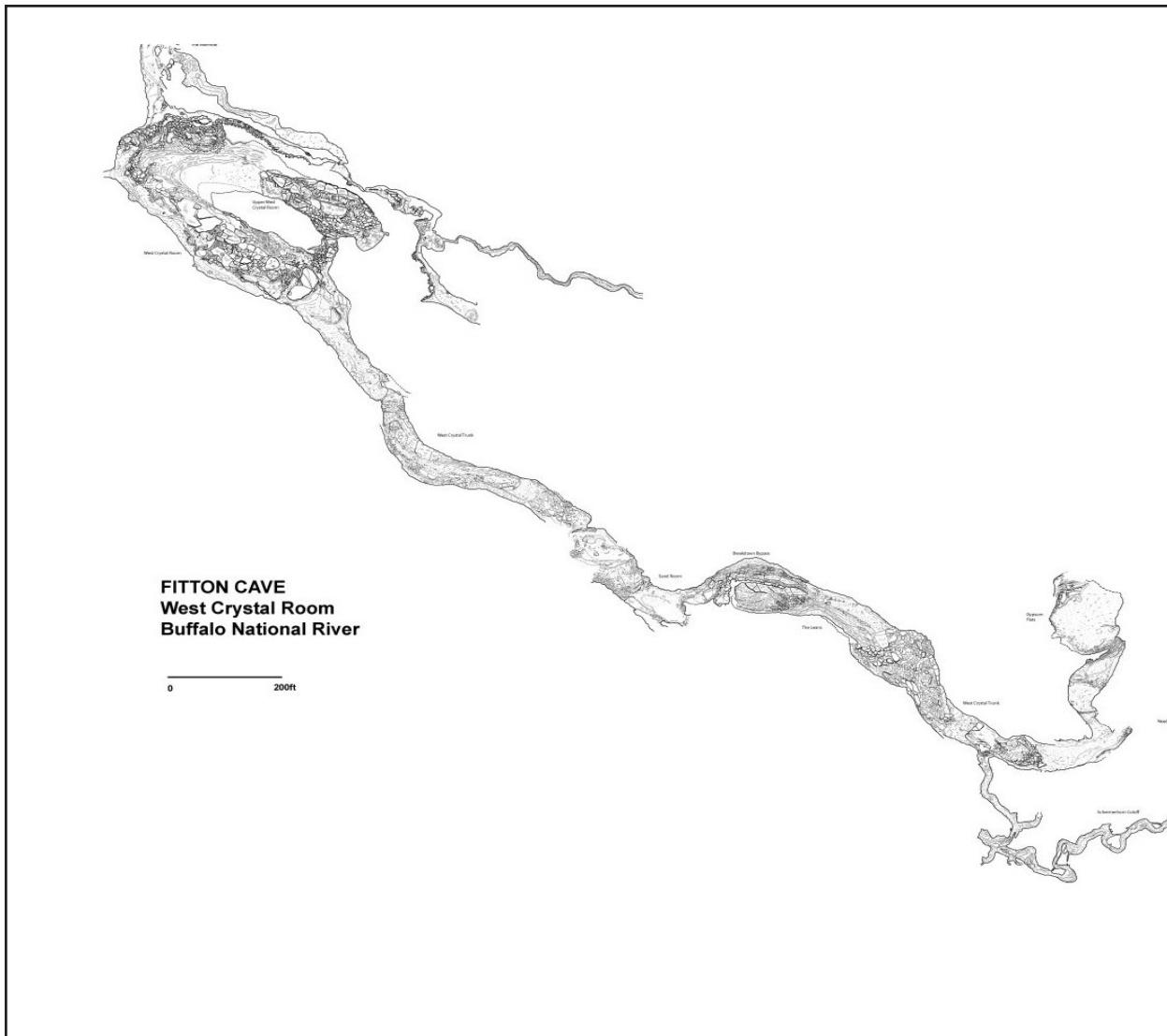
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(Note: at the time of this writing, January 2010, most caves within Buffalo NR have been closed to recreational caving.)





CRF also has helped maintain and improve the Steele Creek Center, which is devoted to research and educational purposes. CRF members cleaned areas around the building, assembled

new furniture, and otherwise help make modifications to the interior that enable it to be more functional for its purpose.

## Missouri Cave Database

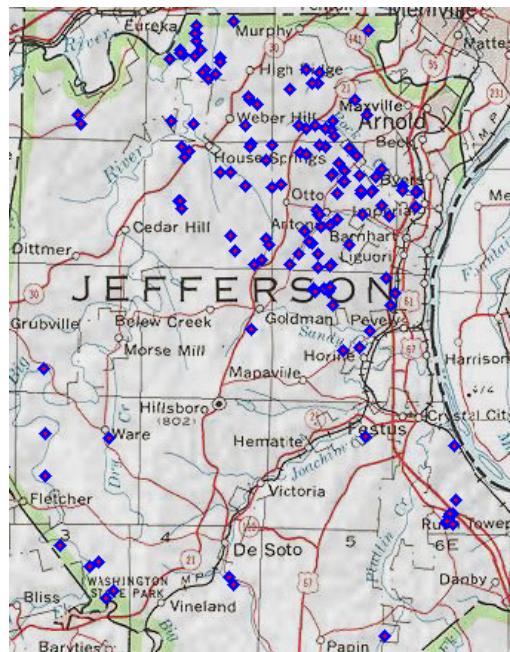
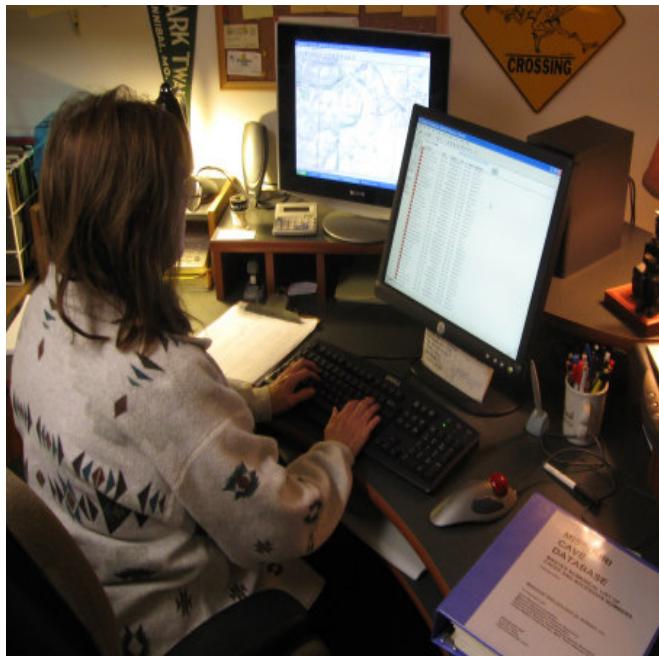
Scott House

The Missouri Cave Database is a project of the Missouri Speleological Survey. Cave Research Foundation provides support in the form of office space, computer hardware and software, along with personnel and financial support. The database is written in FileMaker Pro, currently kept in version 8.5. Since the file contains minimal graphics, it is currently only 43mb in size, maintaining some portability.

The database contains records from state and federal agencies, who rely on the MSS to provide a consistent numbering scheme, as well as providing review and auditing of cave locations and names.

As of the end of December 2009, the database includes records on 6448 cave entrances, most of which are to unique caves (some are to multiple entrances of the same cave system). During 2008-2009, nearly 200 new caves were recorded along with hundreds of location improvements and hundreds of new reports. New reports may include memos, narrative descriptions, biological reports, or email discussions.

Cave maps are turned in separately and archived with the Missouri Department of Natural Resources, Division of Geology and Land Survey.



Database work and sample of output Photo and graphic: Scott House

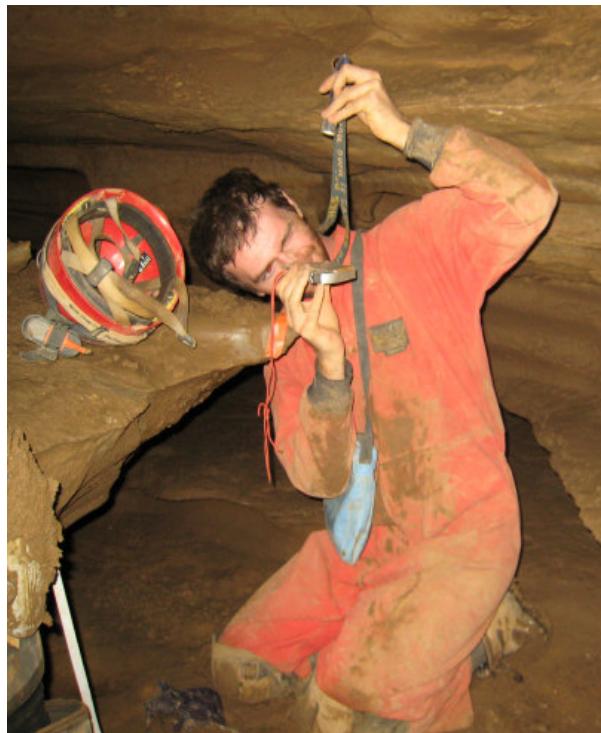
## Mammoth Cave Cartography

*Ed Klausner and Jeff Bartlett*

Cartographic work for the Mammoth Cave System has always been split up into a series of manuscript sheets with assigned cartographers. However management of digital survey database has been problematic.

Once a decision was made to change the management of the Mammoth survey data, it still had to be implemented. In the past, individual cartographers maintained Walls data for their map sheet. There are a number of problems with this. First, large loops weren't included so the survey line would be incorrect once loops were closed. Second, passages have the nasty habit of going off the edge of one sheet onto another, and sometimes onto yet another. That makes the maintenance of the data difficult when it is across boundaries. Third, not all cartographers were using Walls, so combining datasets would have been a problem. The solution was to have four sections with a single person responsible for all the data in that section. The four sections are: Mammoth Ridge, Flint Ridge, Proctor and the river system, and Roppel Cave.

The data for Mammoth Ridge was brought into one dataset during a cartographer's meeting in Missouri in February of 2008. Since then, the walls data has been checked for proper compass corrections, obvious tie errors, and to the extent possible, duplicate survey has been removed. The benchmark data was replaced with accurate GPS locations of the entrances that were gathered by Bob Osburn and Aaron Addison. This eliminated the use of the calculated locations of the Walker benchmarks that were causing problems. Many of these benchmarks were found to have incorrect coordinates and many had already been removed as fixed points in the data net. By removing the benchmarks as fixed locations, some of the loop closure problems we've had on the ridge have been eliminated. The benchmarks are now survey stations that are

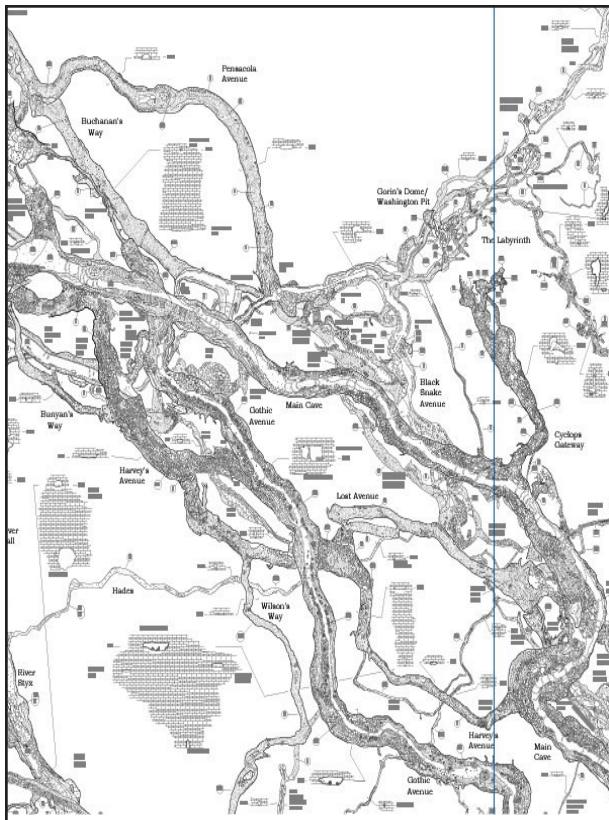


Surveying in the Mammoth Cave System

similar to recoverable, easy to find poker chip survey stations. The total survey length for Mammoth Ridge now stands at a bit more than 150 miles.

### *Historic map sheet*

All the existing survey for the Historic map sheet has been drafted in Illustrator. Doug Baker's tourist trail map was used for much of the upper level tourist trail. Quite a bit of new survey has been done in the past two years. River Acheron was discovered at the bottom of Procrastination Pit in Gallows Avenue by Rick Olson. This has added over 2200 feet of survey and the passage is still going. An upper level in Watson Trace was discovered and now that it has been flagged off by George Crothers to protect artifacts, the passage can be surveyed. The same is true for Robbins Run near Vanderbilt University Hall. A connection was surveyed between Carlos Way and River Styx (about 750 feet of new survey). In all, there were 37 survey trips to the Historic section in the last two years. The park



Part of the Historic Section manuscript map of the Mammoth Cave System. Cartography by Ed Klausner

requested a map showing the relationship between Dixon Cave and part of Mammoth. This has been produced by drafting Dixon on the Historic sheet as several separate layers in Illustrator and then masking out part of Historic to only show what the park wanted to use for their display. The park has also requested a version of the Historic sheet that shows the lower level tourist trail. This has been accomplished by using a mask for the upper level that allows the lower level tour trail to be visible. This technique was based on Mick Sutton's use of masks on his Salts map sheet.

#### *Albert's Domes map sheet*

Bill Steele, Diana Tomchick and Will Harris confirmed in the cave that there was a blunder in the walls data (compass shot reversed) and the two passages that are north of Albert's Domes have been redrawn to show the correct location.

Some survey was done in the Albert's Domes area and this has been drafted on the map sheet.

#### *Cleveland Avenue West map sheet*

The lower level of the map sheet was finally put into the Walls dataset with the rest of the ridge data in February 2008. This allowed Belfry, Opossum and Stevenson to be drafted along with the Mystic River tributaries. There have been several trips to Stevenson, Opossum and Belfry with several hundred feet of new passage found along with some resurvey of the downstream portion of Belfry Avenue. There have been several trips to the upper level of Bishop's Pit using an extension ladder to access the area. About 700 feet of new survey has been added above Bishop's Pit.

#### *South Downey Avenue map sheet*

Several resurveys were done in this section of Roppel since there were problems with closure of the Walls dataset. The resurvey fixed the problem leading us to believe that the major passages should be resurveyed (not resketched) before any additional drafting was done. Unfortunately, Roppel is not currently a destination of survey trips during CRF expeditions due to White Nose Syndrome restrictions. Hopefully, this will be remedied so work can continue on this map sheet.

#### *Big Rift quadrangle*

Since Jeff Bartlett assumed responsibility for the Big Rift quad in September, 2008, a total of ten trips trips were fielded up the river, netting 3,750 feet of new survey and 4,613 feet of resurvey. The major cutaround known as the X-Loop was resurveyed in a monster two-team effort led by James Wells and Peter Bosted, leaving permanent stations at each lead to facilitate further survey. One especially-gullible team led by Jeff Bartlett carried a four-piece sectional steel ladder in order to check high leads, and was rewarded with a minor breakout. Subsequent surveys above the chert beds here have pushed the

survey line upward into the only known upper levels in the region — a series of canyons and tubes — resulting in 3,000 feet of virgin cave (so far).

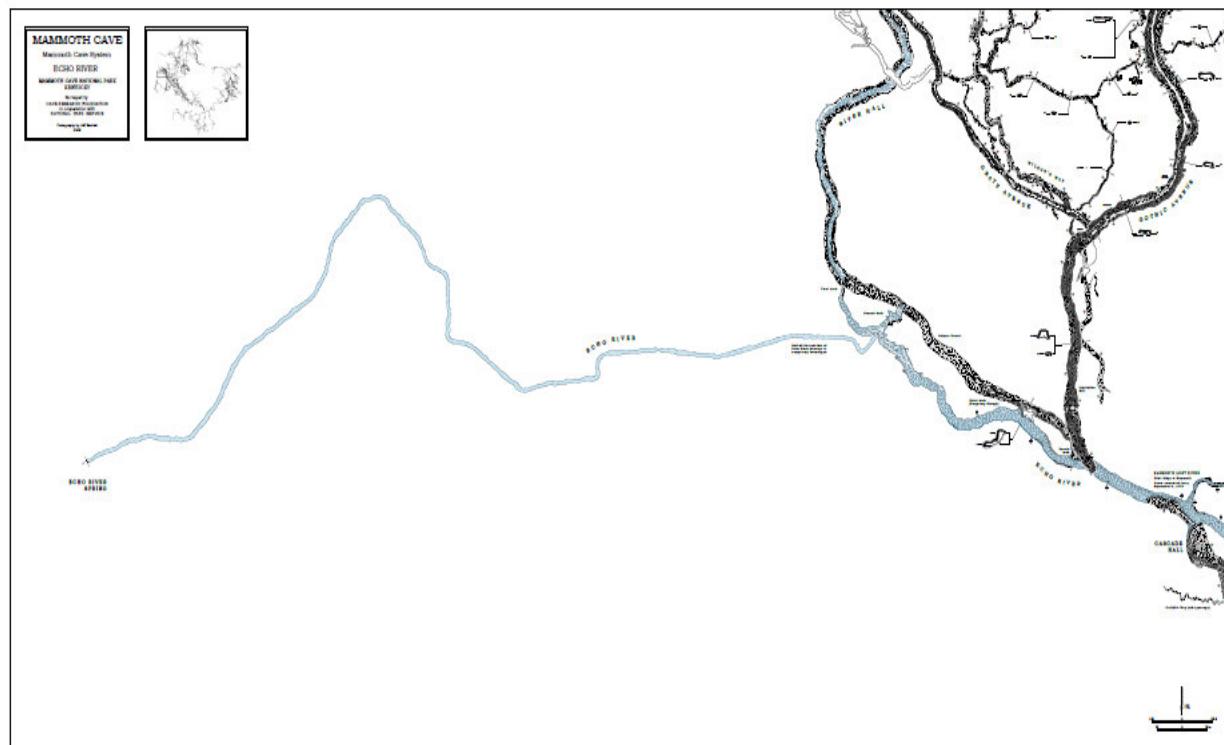
All of the existing surveys on this quad (approximately 18,000 feet in total) have been drafted in Illustrator, including the 2008-2009 extensions, and many exciting leads remain.

#### *Echo River quadrangle*

In June, 2009, Jeff Bartlett began working on this quad. Trips were fielded in short order to replace a 208 ft section of sketch previously missing from River Hall and replace surveys in the deep-water portions of Echo River which were previously absent from the modern data set. These efforts were quite the interesting

challenge, without the luxury of wooden boats like our predecessors, and teams performed 1403 feet of survey with the use of inflatable kayaks, inflatable rafts and some less-glamorous flotation devices. An electronic fish finder was used to ascertain water depths throughout this passage. Efforts have also been made to include survey from a 1981 dive through Echo River Spring and into River Hall, but there is no sketch, and we only have crudely-reduced data from an old plot to work with.

Gothic Avenue is now drafted in its entirety, a portion of which was provided to the Park for a project. Cartography is progressing on the Echo River, River Hall and Cascade Hall areas, including the original Mammoth – Flint Ridge connection.



Echo River quadrangle of the Mammoth Cave System. Cartography by Jeff Bartlett

## **Hardin Butte - Castle Flow Project**

### **Lava Beds National Monument**

*Scott House*

In October 2006, during the CRF annual meeting, a group of eastern (east of the Great Basin) CRF members asked about surveying a cave that could be finished in one day. We were taken to Township Cave, in an area of the park remote from the bulk of the accessible lava tubes. This tube area lies to the north of the park's major landmark, Schonchin Butte, and is in a flow originating from the Castles, a series of large and irregular spatter cones. This flow is younger than, and erupted through, the major flow in the park which originated from Mammoth Crater. It is also younger than the massive Schonchin flow to its east. (All of these flows are considered to be late Pleistocene in age.) The Schonchin flow is an impenetrable feature composed of aa and block lava. The Castle flow is mostly surface pahoehoe which, although broken up, is far easier to traverse. The major topographic feature of the flow area is Hardin Butte, a cinder cone somewhat older than the flow which surrounds it. Hardin Butte serves as a navigational aid while traversing the area. The 1987 geologic map notes describe this flow thusly: "small surface tubes are common, but development of major lava tubes did not occur."

Two crews completed the survey of Township Cave easily in one day. However, as in most tube areas, a collapse sinkhole entrance had another entrance on the far side of it. This was surveyed for 150 ft and was left with two good blowing leads unsurveyed.

We returned during the CRF National Expedition in October 2010 to finish the leads.

One of the leads of Township North Cave (tentative name) ended in clean fashion but the other led to a series of passages and other entrances. This required yet another trip to finish. Meanwhile surface surveys were run to another small cave in the immediate area. This one, tentatively Altar Cave, had three entrances and required another trip to finish. And during this survey, yet another cave entrance was identified. Two trips were necessary to finish this cave and tie it into the net.

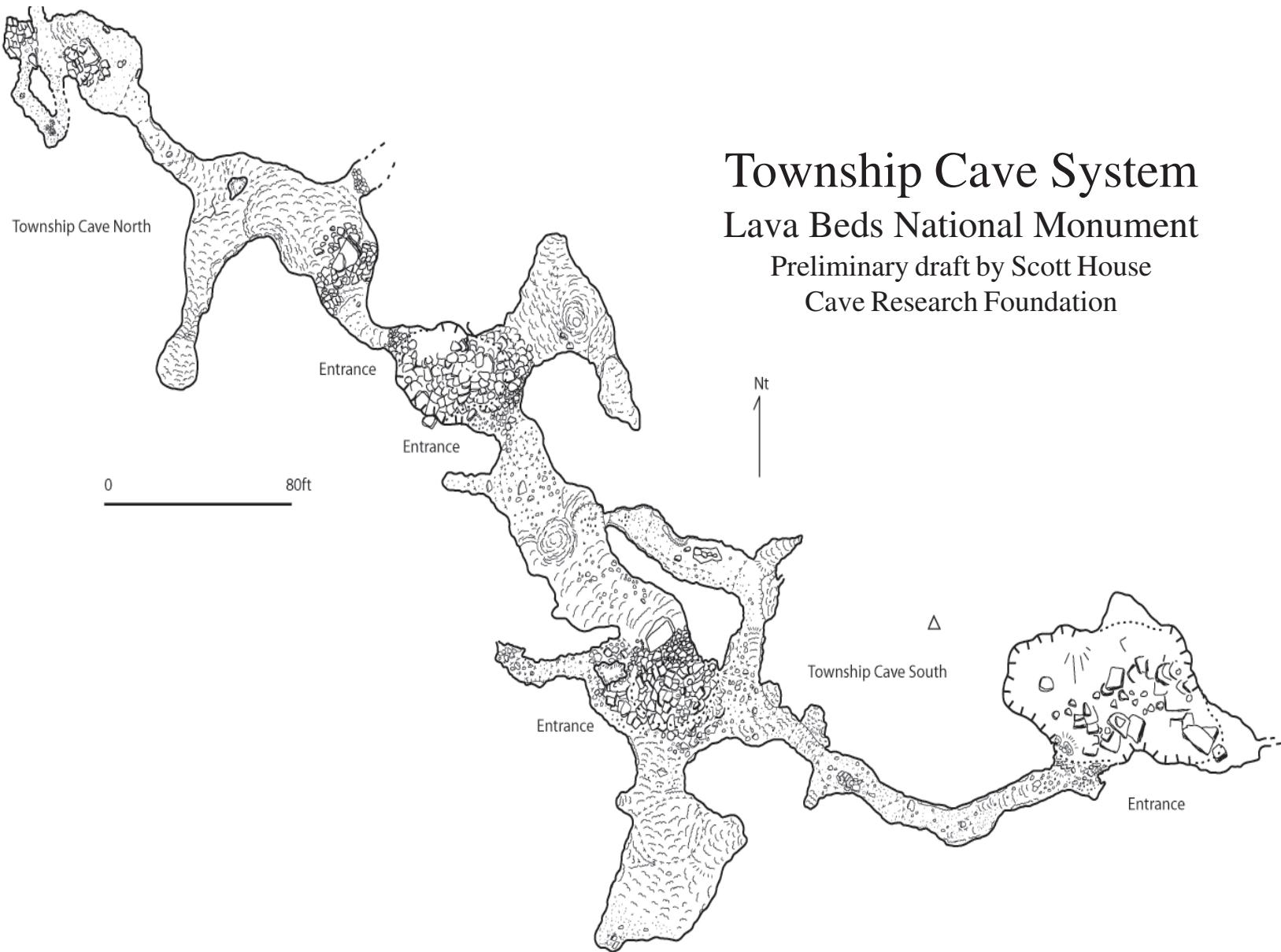
Down-flow and north of the Township Caves another cave was identified, tentatively named Corral Cave. A survey was begun in it but has not yet been completed. Lastly, a surface recon of the up-flow area south of Township revealed numerous cave entrances. GPS locations and digital photographs were obtained of these entrances; none of these caves were entered since we follow a survey and inventory-as-you-go policy.

It is projected that we will continue surface surveys to all of the caves, documenting sinkhole and other features along the way, and then surveying the caves themselves. At the same time, resource inventory will be done. The area is sensitive culturally, owing to Native American usage and the presence of a battlefield (1873 Modoc War) on the south end of the flow. So far about 3000 ft of cave survey has been completed with another 1500 ft of surface survey done.

Work is just beginning. Many thanks are given to the various surveyors as well as our Lava Beds National Monument hosts and CRF facilitators.

# Township Cave System Lava Beds National Monument

Preliminary draft by Scott House  
Cave Research Foundation



# Cartography of Caves in Redwood Canyon

## 2008-2009

*Jed Mosenfelder, Chief Cartographer*

Survey and exploration of Lilburn continues at a moderate pace, with almost 1800 feet of new survey and 850 feet of resurvey completed in the last two years. This brings the length of the cave to 21.43 miles.

Much of our work in the past two years has concentrated on resurvey and redefinition of known areas where the map seems particularly inaccurate. The South Seas, currently shown as a large lake, was extensively resurveyed to define the complex boulder pile that it actually is. In the process, a climb with intriguing airflow was found and pushed to a window in the middle of a large dome. This turned out to be Splash Down Dome, inaccessible from the bottom for many years since it was first surveyed in 1987. We also connected to this area by dropping down from the top (Southern Comfort) and swinging over by pendulum to the window, completing a huge loop through the cave. At least one excellent climbing lead remains here.

The most substantial new find was a multi-level room dubbed “La La Land”, in an upper level above the Yellow Floored Domes. This area was accessed via an obscure, somewhat tight climb. The room and adjoining passages were surveyed for a total of about 500 feet and the quadrangle and two adjoining quadrangles were completely redrafted; the new M2U quad is shown in Figure 1.

Other highlights of exploration and cartography included difficult climbs near the Red Cup Formation (above the Lake Room) and in the Outback; an intriguing crawl heading off the map near the White Rapids, which unfortunately ended in a tight sump; “mop-up” trips to the Attic, the VK survey, M2L quad (below River Pit Avenue), and Southern Comfort; and resurveys in the south end off River Pit Avenue (near station R1) and of the active dig site heading north off the Power Kleinbottle complex.

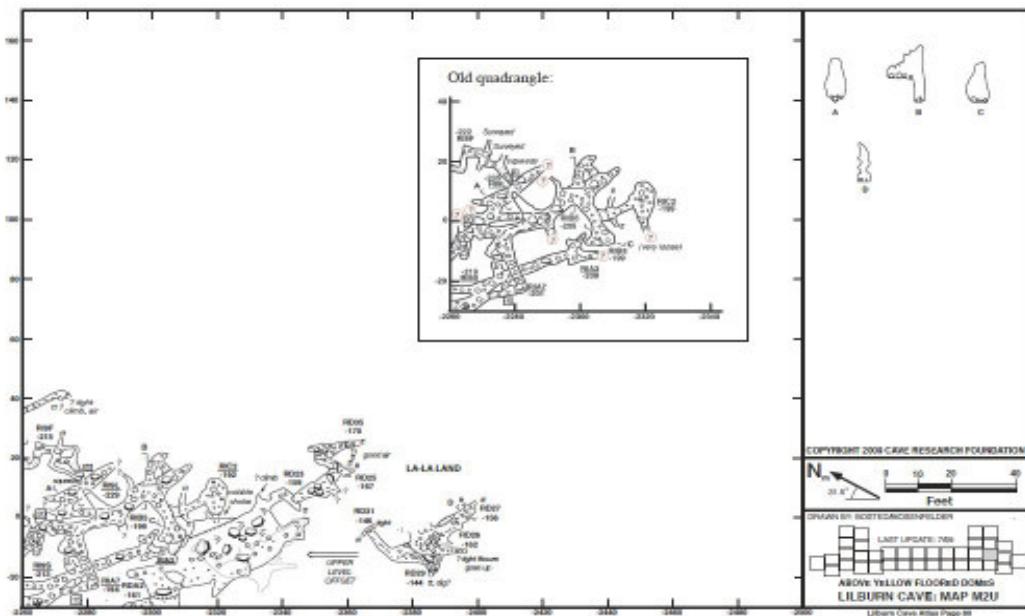


Figure 1. Updated quadrangle M2U, showing part of the new area called “La La Land” and the old

## 2009 Mojave National Preserve (MOJA) Report

Bernie Szukalski



Andy Gup at the entrance to Arrowhead Shelter Cave, previously reported but only recently logged into the database. Photo: Bern Szukalski

The Mojave Cave Survey, a small and seasonal project, continued during the 2009 season with a number of activities. Project work included ridgewalking trips to locate caves, field checking and obtaining GPS coordinates for previously reported caves, and the survey and inventory of small caves, shelters, and historic features throughout the preserve. The Mojave National Preserve currently has a database of approximately 60 caves and shelters, the longest of which is Warners Cave at 335 feet (nearby longer caves located within Mitchell Caverns State Park and other areas not within the Preserve boundary are not included in the Mojave National Preserve database). The small dimensions of most caves makes this project mostly a ridgewalking one, with many square miles accessible only via

unimproved or 4x4 roads with sometimes lengthy off-trail hikes.

Significant finds this season included the discovery of a collection of handprints in a shelter cave in an overlooked area along the northern end of the preserve. The cave was aptly named Handprint Shelter. Coral Buddha was located, inventoried, and surveyed. This cave is one of the most remote in the Preserve, and was discovered in 1988. The cave, located deep within a canyon and high up on a cliff, has been lost for many years and has only seen a handful of visitors. Sweet Surprise Cave, the most highly decorated cave in the Preserve, was also visited to check to see if it has been disturbed. This cave is currently ungated, protected by its remoteness

and long trail-less approach hike with a 2,200-foot elevation gain - no signs of visitation were noted. Shaman's Cave was also visited, and petroglyphs recorded nearby. Other small shelters and caves were surveyed and logged, becoming part of the slowly but continually growing MOJA database.

Projects for the coming year include searching other areas with a few known caves to seek more, and a reorganization of the entire database and correlation of duplicate records and notes dating back to the 1970s. Those interested in participating can contact Bern Szukalski (contact info found in the NSS Members Manual).



Preserve resource specialist Ted Weasma admires the little coral Buddha in Coral Buddha Cave. Photo: Bern Szukalski

## **Whigpistle Cave Survey and Expeditions for 2008, Edmonson County Kentucky**

*Joel Despain, Pat Kambesis and John All*

Members of our informal Whigpistle Cave Project group completed two week-long survey expeditions to the cave in 2008. These trips have been popular with California cavers and many West Coasters have made the trips over the last couple of years. The trips were in March and July. Most leads were pursued using the Martin Ridge entrance to the system.

We are very grateful to the individuals who have worked in the Whigpistle and Martin Ridge sections of the cave in the past and who have shared their notes and data with us. We could not continue to work in the cave productively without their support. We also must thank the landowners for all three entrances to the cave who have encouraged our work and been a pleasure to talk to and interactive with. We must thank the NSS, which provided us with a very helpful Sara Corrie grant, and the Hoffman Environmental Research Institute at Western Kentucky University, which also provided a grant to support the project.

On March 13 Shane Fryer, Nick Barth, and Joel Despain headed to Petit Hollow (named for Art Petit, a Tennessee caver) via the Martin Ridge Entrance. This is a great and varied caving trip with fun rope work, deep mud, long canyons, some large trunk, streams, and dry upper levels all leading to a tight blowing lead. Past the mudman and the last survey station left by Michelle Karle and Alan Glennon in June 1997, we wriggled on pinched between a bedrock ceiling and a floor of hard mud. After some 60 feet the passage narrowed considerably. Nick and Shane managed to continue, but about a body length in, my chest was pinched, and I was stuck. I backed out to wait. My two narrow friends continued through another squeeze to a dig (also the last point reached by Alan). Shane said, "I could

smell the passage on the other side" and he and Nick began to excavate. I could hear their muffled efforts for an hour and a half, and then suddenly all was quiet! Fantastic, I thought! Within an hour I could again hear cavers vs. tight passage approaching me. The dig had gone to reasonable-sized walking passage that continued with the air. Most excellent!

The next day we returned with Cyndie Walck and Jed Mosenfelder. The three of us planned to survey past Alan's station to where my traverse of the passage had ended, allowing Nick and Shane maximum time to survey through and past the major constrictions. Soon we were calling the passage Don't Have Kids Crawl, as those with children consistently couldn't fit. Jed soon became bored and got busy on more mud sculptures while Cyndie and I knocked off what was really a two person survey anyway. When we were done we took on another side lead at the bottom of Pendulum Pit. It was wide and wet and soon became low and wet with no air. We ended the day with only a few hundred feet in the book. But, as expected Shane and Nick did better and surveyed 965 feet of small and dry walking passage trending east southeast. They turned back late in the day with more in front of them and the air in their face.

On July 26 Nick and Pat Kambesis (from central KY) fought their way back through the very tight Don't Have Kids Crawls and returned to the going lead. They surveyed 386 feet and ended at a moderate-sized crawl, still with good air. We will return.

In August 1997 Alan and Jon Jasper completed the survey of Quinlan Creek, one of the longest streams in the cave at just over a mile in 180 stations (some of this had also been surveyed

by the original Whigpistle cavers in 1983). The creek finally sumped in a large room full of deep soupy mud. Their notes showed a lead at the south terminus of the room with “howling wind” emerging from a 1’ x 1’ hole with 5 inches of air and 7 inches of water. I was intrigued by this lead on the edge of the cave and headed toward what should be the master stream of the area flowing north from Mill Hole on the way to Turnhole Bend. Nick, Paul Burger, Jed Mosenfelder and I headed for lower Quinlan Creek on July 21. Jed and Paul took on a side passage that we at first suspected was a cut around to Quinlan Creek. This proved not to be the case and they surveyed a significant side passage as well as a wide sandy cut around. Most of the side passage was roomy, muddy walking passage with a small stream. They ended at a continuing crawl with some airflow and with 660 feet in the book.

Nick and I headed for the lead near the sump. To our delight things had changed. We still had the “howling” air but the passage was larger – perhaps 4 feet wide and 18 inches high, but still with lots of water. Nick dove in (literally) and quickly pushed through the low air space into a roomy crawl with only an inch of water on the floor and all of the air. He reached a small natural bridge that blocked the passage and returned. We decided not to survey as we needed a hammer for the bridge and a trowel to dig out the low airspace.

We returned on the 23rd. Paul is half fish and impervious to cold temperatures. I asked him to take a stab at digging out the low water crawl. He dove in and completely submerged himself in the muddy water while wearing merely a T-shirt and saying, “I do what I am told.” Twenty minutes later our tight water crawl was very roomy and Paul had finally stopped sweating. Out came the tape, instruments and book and on we went. The tiny natural bridge gave way to a hammer with just a couple of blows. I was in back with the book, but up ahead Nick and Paul seemed excited as we progressed. After nine shots we



Jed Mosenfelder dropping a virgin pit

emerged from the crawl into muddy walking passage heading west into unknown territory. Yea! Soon we reached a large dome leading to upper levels. One we were able to enter and survey following the westward trend. This led to a half-dozen smaller domes and finally a sump. But, where was the air? Back in the first dome an apparent large upper level seemed to be where our wind was headed. We will have to return prepared to complete a lead climb to continue. We finished the day with 680 feet of survey.

During the March expedition teams completed several mop-up surveys near Pendulum Pit. This is a relatively mazy area and we completed 825 feet of survey on three trips.

At Screaming Pit at the south end of the greater Martin Ridge Entrance complex, Jon and Alan had left some small leads and the pit unsurveyed. In March Pat, Shane, Cyndie and I surveyed down the pit from the lower passage accessing it and onward past a couple of waterfalls to a three way junction and a stream. We had

limited time on the trip and mapped only 200 feet. We returned in July and surveyed 330 feet in three passages that ended quickly in a sump, a breakdown choke, and a mud plug. We left at least two good-looking lead climbs that will be our primary objectives in the area in the future.

Ben Miller and Bob Lerch began the July expedition with a trip to the P and PA surveys in Martin Ridge. We are missing these notes from Jon and Alans' work in the 90s. They completed a couple of hundred feet of resurvey and located a promising lead.

July also included our first trip to the historic Whigpistle Entrance of the system. It was great to get into this section of the cave where 22 miles had been mapped in the 1980s. This entrance is notorious as a flooding hazard and hot and dry July was the perfect time to go in. Not knowing this part of the cave, we had a few moments of uncertainty but we found our way through this somewhat complex part of Whigpistle. At the entrance we reluctantly donned our wetsuits on a muggy July day. Luckily water levels were low in the cave and the few clouds overhead never coalesced into rain. Since we did not have to worry about flooding, the trip in was enjoyable with scenic scalloped canyons and a pretty little stream. Aaron Bird was checking every hole as we went into the cave. Along Travertine River, he looked into a canyon that rapidly led to a dig, but had good air. He and Nick decided to dig a bit and see what they might find. Jed and Paul and I headed for a small lead nearby where the stream from the Wimp Entrance to the cave joins Travertine River. We had surveyed about a dozen small shots into our small passage when sounds of Nick and Aaron coming to find us could be heard. We emerged from our hole to sounds of, "it goes." We headed back to their lead. They had dug into a canyon passage with a small stream and up and down hills of mud that led to an extensive dome complex with an obvious canyon lead 20 feet of the floor. We will be back to do this climb.

Another trip went to the South Trunk of the Martin Ridge section of the cave. There were several small leads in this area, but unfortunately nothing went. We have started to call this classic trunk passage Mill Hole Ave since it heads straight south and directly toward Mill Hole.

Our most exciting July trip was to the central segment of the Dreamland Borehole (the western-most section of this major trunk passage is called Yoh Avenue within Whigpistle proper) and the "Death Ledge." It is a fun trip out to this area except for a wet crawl several hundred long that must be traversed before reaching the borehole. We had spent a lot of time in the eastern-most segment of this passage, which is part of the connection to the Jackpot area of the cave. Here the passage is muddy and perhaps a dozen feet in diameter. But, the central section and the Death Ledge area is grand. The passage is about 50 feet wide with much gypsum and many nice stals. We headed to leads at the passages western terminus. Along the way and at the Death Ledge we were surprised to find a series of 8 promising pits 60 to 100 feet deep. Jon's notes from June



John All at Quinlan Creek

1997 showed depressions in the floor, but we did not realize that these depressions were enticing pit leads. Our lead at the end of the passage was also turned out to be a pit with some air, but we lacked vertical gear. A nice cut around passage became our survey objective for the day and we completed 600 feet of survey past many nice gypsum features. We are excited to return to this area and drop these pits on our next expedition in early February 2009.

Our other major effort in 2008 was working on the maps. We are working to create a quadrangle book for the cave, although completion is years away. Maps are 17 x 11 and are drafted at 50 feet to the inch. Much larger, poster-size maps have also been created for the Jackpot and Martin Ridge landowners. The Martin Ridge quadrangles have been completed

including the new surveys. We are still short of about a mile of survey in the Jackpot section of the cave, but otherwise the rest of this area has also been drafted. There are only a few quads in the Whigpistle section of the cave that have been done. Don Coons has now provided us with his high-quality pencil draft of the historic Whigpistle section of the cave and many members of the group have now volunteered to draft quads, including Don. This will make for fast work for drafting these quadrangles in the future, and we look forward to making steady progress 2009.

Currently the Whigpistle Cave System (comprising connected Whigpistle, Martin Ridge, and Jackpot caves) is 180,936 feet or 34.27 miles or 55.17 kilometers long. But there is much more to be found and much fun to be had exploring this amazing Kentucky cave.

### Whigpistle Cave



# Restoration, Conservation and Education



Elaine Garvey and Chuck Lee doing restoration work at Lilburn Cave. Photo: Bill Frantz

## Lilburn Restoration Project Report

*Bill Frantz*

The long running exploration and scientific research activities in the caves of Redwood Canyon, dating back to the late 1940s, have had adverse impacts on the caves. In particular, sediment and mud have been tracked and dropped onto previously clean formations. The primary goal of the Redwood Canyon Cave Restoration project is to mitigate human-caused impacts in Lilburn Cave and other caves in Redwood Canyon.

Soiled formations are cleaned using water spray, water flooding and scrubbing with soft brushes. In severe cases, as a last resort, physical or chemical removal of thin layers of calcite may be used to release detrital particles from the surface of the cave's secondary formations. Restoration begins with techniques that produce the least adverse impacts on the cave. More aggressive techniques may be employed as required to achieve a visually improved result.

In addition, trails in frequently traveled areas, and in those that traverse decorated reaches of the caves, may be flagged to designate routes that minimize the potential impact on formations, substrates, and cave habitats.

For the past several years, we have been cleaning formations near station BX4. In 2009, we completed this work and flagged a route that will avoid the formations. We have also continued to monitor areas previously cleaned.

We see good progress in the natural recovery of the floors in the north part of Pandora's room. The Glacier area seems to be maintaining

itself, but there are still rock particles in the flowstone dams that were introduced recently.

An interesting case for restoration policy is the drops of mud on the dry flowstone below the Jefferson Memorial. Lore from long-time Lilburnites has it that this mud fell on the formation while upper-level passages were being checked. Since the upper-level passages did not go anywhere, the have remained unvisited ever since. In 1994, all the drops of mud were removed from the flowstone. Over the following years, new mud drops have appeared. It appears that these mud drops may be a natural occurrence. So the question is, should they be removed?

During 2008-2009, project helpers were:

Kelley Prebil  
Jim Castelaz  
Tim Ramsay  
Dave Bunnell  
Hannah Whitehouse  
Kyle Dwyer  
Robert Darrah  
Damian Grindley

## New Gate on Round Spring Cavern

*Scott House*

With the help of a large contingent of Missouri cavers, CRF organized the building of a new gate on Round Spring Cavern in Ozark National Scenic Riverways. Round Spring Cavern is one of the jewels of the National Park Service System. The 6000 feet of surveyed passages contain vast displays of secondary mineralization, known as speleothems, as well as important historical, paleontological, and biological resources. The cave was developed for commercial tours in the early 1930's, acquired as part of the creation of the Ozark National Scenic Riverways, and continues to be shown to visitors throughout the summer months. The original commercial gate was replaced by the NPS in the 1970's. Over time, that gate deteriorated; further its design, although good for its time, was outdated and detrimental to bat populations in the cave.

A new cave gate was proposed to the NPS by Cave Research Foundation in 2008. Funding was found through a challenge cost share grant of the NPS. In order to keep down costs, leftover steel from previous projects was to be utilized and much of the labor cost was minimized using donated time.

The gating had to be done over a four-day period at a time when tour attendance is relatively sparse and it was possible for the cave to be closed to visitors. Work began well in advance with a design by Jon Beard and Scott House. Charley Young of Springfield Plateau Grotto built the door assemblage at his own fabricating shop. The National Park Service moved steel from various locations to the Round Spring parking lot, while at the same time assembling gas tanks, generators, and tools on site. Jim Cooley of Kansas City worked with the park to get logistics worked out. Others arranged for cords and other equipment.



Work began on Wednesday, August 19, 2009, with a small crew cleaning steel and organizing tools while the last tours went through the cave. On Thursday as people showed up, the gate trench was excavated and uprights were cut. Friday, with even more people present, the three uprights went up plus a sill and one horizontal piece were installed. The bulk of the gate was assembled on Saturday with 25+ volunteers present. A fabricating center was operating in the parking lot while other crews carried assembled steel up the hill as the welders assembled the pieces in place. On Sunday morning the last of the steel was assembled as the old rebar gate was cut out. The trail just inside and outside of the gate was reconfigured and widened, a big improvement. By Sunday afternoon the work site was all cleaned up, tools packed, and excess steel

ready for the NPS to transport. By Monday morning the cave was ready once more for visitors to take tours.

This was a big effort due to the complicating factors of trying to make a presentation-quality gate under a severe time constraint. We felt confident that we could get it done if enough people showed up to help. We never really expected, though, that we would have more than 25 people, a substantial number of whom were experienced metal fabricators with their own equipment. In addition to CRF and NPS the following organizations took part: Springfield Plateau Grotto, Meramec Valley Grotto, Kansas City

Area Grotto, Pony Express Grotto, and the Missouri Caves and Karst Conservancy.

Participants included: Scott House, Jim Cooley, Joe Williams, Earl Hancock, Lannis Hancock, George Bilbrey, Alicia Lewis, Jon Beard, Charley Young, Max White, Bill Heim, Kevin Helton, "Bear" Helton, Pic Walenta, Joel Laws, Ray Mallinckrodt, Shawn Williams, Tony Schmitt, Mick Sutton, Ben McCall, Kyle Riggs, Lorin O'Daniell, Roy Gold, Jack Rosenkoetter, and a few folks who helped out and whose names I didn't catch.



## Cave Restoration at Ozark National Scenic Riverways

*Scott House*

Funding for a several year project to perform cave restoration at Ozark National Scenic Riverways (OZAR) was provided by the National Park Service. The project had four goals:

1. Restoration of cave floors and walls at no less than ten caves within OZAR.
2. Restoration of habitat in four public use caves within OZAR.
3. Creation of three interpretive displays at highly visited caves containing endangered species.
4. Creation of an interpretive brochure on caves.

The project went on longer than anticipated and results were greater than imagined. Much of the hands-on restoration work was done by CRF's project partner, Springfield Plateau Grotto (SPG), whose members are well-versed in proper restoration techniques.

### *Granite Quarry Cave*

A major pothole in the entrance passage was filled and the floor restored to a natural appearance. Trash and non-historic graffiti were removed. This cave is administratively closed to encourage restoration of bat populations.

### *Little Granite Quarry Cave*

Trash was removed from this cave. Historic graffiti was not removed.

### *V-Tree Cave*

A long trench dug in the entrance by archaeological vandals was filled and the floor restored.

### *Johnny Hollow Cave*

A pothole in the entrance area was filled and floor restored.

### *Devils Well*

The stairway and landing was cleaned on three occasions to allow visitors to safely descend the stairs to the viewing platform.

### *Smokehole Cave*

A pothole in the floor of the cave was restored to a natural appearance.

### *Lost Man Cave*

This cave is permitted during the summer and closed in the winter to allow cave species better use of the cave environment. Extensive graffiti (mostly spray paint) was removed from the cave. Trash was also removed. A small number of speleothems were restored to proper positions and areas of flowstone were washed, restoring the cave to a more natural appearance. Salamander breeding pools were delineated and cleaned.

### *Meeting House Cave*

A major excavation in the cave floor was largely refilled with several tons of rock and dirt debris. Several bolt hangars were removed from the cave wall. Fire rings and graffiti were also removed and the floor naturalized.

### *Branson Cave*

This cave, one of the top biodiversity caves in the state of Missouri, is permitted during the summer and closed during the winter to encourage bat usage. A trail was designated within the cave to constrain visitors to a path throughout the main passage. Salamander breeding pools were restored.

### *Welch Spring Cave*

Trash was removed from the cave entrance area. This cave is administratively closed to protect habitat and the rest of the cave has only older modifications in it that do not require restoration.

### *Bunker Hill Cave*

: Trash and non-historic graffiti were cleaned from the cave. Water sprayers and brushes were used to remove the graffiti.

### *Medlock Cave*

The floor area just inside the gate was restored to a more natural appearance. Graffiti on the bluff face outside the gate was removed. This cave is administratively closed to protect endangered bat species.

### *Big Spring Anastomosis Cave*

Extensive graffiti was removed. An old gate structure, made of treated wood (poisonous to cave life), was removed from the cave.

### *Bear Cave*

Major potholes in the floor of the entrance chamber were filled, smoothed, and the floor restored. Old wood was removed from the cave stream after biological inspection showed the wood was not being used as habitat.

### *Rockhouse Cave*

Trash and minor graffiti were removed from this cave.

### *Courthouse Cave*

Trash was removed from this cave.

### *Luther Williams Cave*

Trash was removed from this cave.

### *Merritt Rock Cave*

Trash was removed from this cave.

### *Bluff Cave*

Bluff Cave is a permit cave during the summer months and is closed during the winter to encourage use by bat species. Graffiti was removed from the cave walls. Relatively recent trash was removed. The gate was repaired and partially replaced. Over sixty speleothems were restored to natural appearance through the use of drill-coring and inert epoxy. Salamander breeding pools were delineated to keep visitors out of them. Some formations had to be removed to a remote site in order to reassemble them. Restored speleothems in the cave were flagged during the work; flagging was later removed.

### *Little Bluff Cave*

Graffiti and trash were removed from this cave.

### *Round Spring Cavern*

This is the park's interpretive "show" cave. Developed trails within the cave are mostly clay and gravel which had deteriorated over time presenting a danger to the natural cave environment by visitors falling or bumping into walls, streams or formation areas. The trails were restored and smoothed. The cave is closed except by ranger-led interpretive tours during the summer months. Salamander breeding pools on or next to trails were moved slightly to protect the cave life.

### *Interpretive signs*

A new set of three interpretive waysides are going up in the Ozark National Scenic Riverways (OZAR) as part of a multi-year restoration project. These waysides will interpret the need for cave restoration and how visitors can help. The three signs are unique to each site. One, at Powder Mill Research Center (and Ozark Trail parking area) tells of a vandalized cave that is undergoing restoration. Another sign at the Round Spring Cavern parking area tells the story of this well-preserved cave. The third, at the Akers Ferry Contact Station, features cave life and how we try to preserve and restore habitat.



Interpretive signage at Ozark National Scenic Riverways

This project was partially funded by the National Park Service with matching donations of time and materials from CRF and its partner Springfield Plateau Grotto (SPG). CRF personnel wrote the sign material, assembled graphics, and designed the signs, holding to NPS graphics standards. The sign mounts themselves were built by Charley Young of SPG in his metal-working shop. In this way, a considerable amount of money was saved, making the project possible. CRF and

SPG are also performing the installation of the signs, with cooperation of the NPS.

### Brochure

A brochure telling of the need to protect and restore natural cave environments has been written and printed in PDF format. The brochures can be printed on demand and revised as necessary.

### Techniques of speleothem restoration

Potholes were first lined with archaeological fabric and then filled using spoil dirt from the immediate area. Floors were then naturalized with leaf litter and other material. Broken speleothems were glued with epoxy cements developed and donated by 3M Company. Rocks used to line trails and pools were native materials gathered from loose rock areas near caves. Only water, no chemicals, was used in spraying and scrubbing graffiti from the caves.

### Volunteers

Volunteers came from the Springfield Plateau Grotto, Cave Research Foundation, Kansas City Area Grotto, San Francisco Bay Chapter NSS, Southeast Missouri State University, the Missouri Caves and Karst Conservancy, and the Boy Scouts of America. Over 800 volunteer man-hours were spent on this project.



Close-up of signage



Thus far, more than a dozen caves have been restored so that they are more like their original, natural state. The ongoing cave restoration and protection project in the Ozark National Scenic Riverways is a partnership between the National Park Service, Springfield Plateau Grotto (chapter) of the National Speleological Society, and the Cave Research Foundation. But the ongoing preservation of these caves depends on one more partner - YOU! You can help: when visiting caves travel carefully and responsibly. Stay on marked paths and off of untrampled sediments. Try to keep out of pools of water, which provide breeding grounds for salamanders. Never bother bats or other cave life. Look at, but do not touch, delicate speleothems. Take photographs, but nothing else. Never write your name in a cave. Keep these wonderful natural features pristine for future visitors.



#### CAVE RESTORATION AT OZARK NATIONAL SCENIC RIVERWAYS

The caves within your national park need your help! Caves are an extremely important resource in the Ozark National Scenic Riverways. All caves hold valuable records of earth's geologic past, and some contain records of the way life used to be when now-extinct species roamed the Earth. Numerous caves contain remains or evidence of our own heritage. Many caves within the Riverways are habitats for endangered species and contain fragile ecosystems that cannot survive anywhere else. Some of these species are imperiled by human disturbance.

Entry to the vast majority of the caves within the park is unrestricted by NPS policy. Some of these caves have been damaged or disturbed by a few of the many people who visit the park each year. A small number of caves have been gated to keep out those who would inadvertently or deliberately damage the resources. You can help us by respecting these gate closures and doing your part in helping protect the fragile resources within. Other caves have been posted with signs. Please follow the directions printed on these signs. Some caves are seasonally closed to prevent people from disturbing vulnerable endangered species inside, and are open at other seasons. Gated and signed caves require written permits from the park in order to visit them.



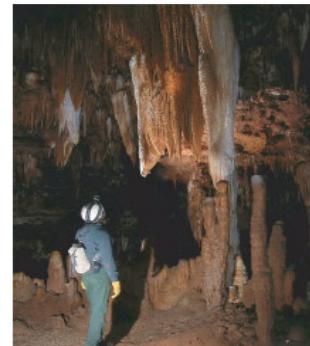
#### Cave Courtesy

**Please...**  
**Wear a hard hat.**  
**Take three sources of light per person.**  
**Carry out trash.**  
**Leave the critters alone.**

**Please don't...**  
**Go alone.**  
**Camp or build fires.**  
**Touch, break, or remove anything.**  
**Write on the walls.**



## HELPING PRESERVE OUR CAVES



#### CAVE RESTORATION IN OZARK NATIONAL SCENIC RIVERWAYS



Several caves are gated to protect two endangered species of bats. One of these species, the Indiana bat, hibernates in colonies in caves in the colder months of the year. Hibernating bats must be left undisturbed because arousal will cause them to use up stored fat too quickly, starving them to death before their food-flying insects become available in the spring season. The other endangered species of bat, the gray bat, uses several park caves as nursery colonies where the young are born and nursed by their mothers. These bats also cannot survive human disturbance. Cave gates help to keep people out during these critical seasons.



Some caves are gated to protect other resources. Digging in caves for any unauthorized purpose is not permitted. The clays and soils in caves hold important information for scientific study. Any disturbance of these sediments destroys all scientific value and renders the features useless. Please help us preserve the integrity of our caves by making no alterations in them.



Park volunteers have been restoring park caves for the past several years. Specialized techniques are used for these processes. Glue provided by a corporate donor allows the reattachment of speleothems such as stalagmites and stalactites. Brushes and water sprayers are used to remove graffiti from walls and to clean muddied speleothems. Damaged mud floors have been smoothed; illegal diggings in the cave floor have been filled and naturalized. Non-historic trash has been removed from a large number of caves. In certain caves, paths have been marked or repaired with border stones to preserve the floor essential for survival of rare and fragile species of cave animals.

Inside and outside view of Cave Restoration Brochure  
for Ozark National Scenic Riverways

## **Ozark National Scenic Riverways**

### **Cave Management Services**

*by Scott House*

Through the national Memo of Understanding and a local contract, Cave Research Foundation provides support and manpower for cave management on the Ozark National Scenic Riverways (OZAR).

#### *Cave Monitoring Program*

Each year OZAR seeks to monitor a number of high-priority caves. Monitoring consists of visiting a cave and checking for public use (or misuse) and obvious cave life. While not a biological survey, much valuable cave life information is gained. Furthermore, any management problems that may need to be addressed are identified. Monitoring is done by CRF personnel, other volunteers, and law-enforcement rangers. Monitoring reports may also be done as part of other trips, such as gate checks or cave survey.

CRF organizes all efforts by CRF and other volunteers for this effort. In addition, CRF enters all data into a FileMaker database, which is kept up to date. In federal fiscal years 2008 and 2009 there were 191 monitoring trips taken, mostly by CRF personnel and other cave organization volunteers. Due to White Nose Syndrome equipment concerns it was somewhat more problematical to get outside volunteers in 2009 but eventually as many monitoring trips were taken as in 2008. Biological observations from these monitoring trips are entered into the Cave Life Database, a cooperative project of the Missouri Department of Conservation.

#### *Cave Management*

CRF provides Ozark Riverways information and review for reports, management prescriptions, cave closures, permit system, etc. CRF provides manpower for installing signage on cer-

tain OZAR caves, including courtesy and closure signs. In FY08 and 09 approximately a dozen signs were installed. These require packing a 24 volt hammer drill into frequently remote locations. In cooperation with the park, CRF maintains a cave management action item "hit list", mostly based on monitoring reports. In this way, needed action gets a high priority. One of the common problems worked on is the maintenance and/or replacement of locks on cave gates.

Two big projects were finished in 2009: an extensive cave restoration project and a new gate for Round Spring Cavern. Both are described in separate articles.

CRF also helps organize the park's annual Cave Management Team meeting. Mick Sutton and Scott House participate in this NPS team.

#### *Cave Data Management*

OZAR participates fully in the Missouri Speleological Survey's cave database. Much new information has been added to this database and to the files maintained in cooperation with the Missouri Department of Natural Resources' Division of Geology and Land Survey. Of the 380 caves within the park's authorized boundaries, approximately 310 are on "fee simple" (i.e. NPS-owned) land while the rest are on state and private lands. Much work has been done in terms of obtaining GPS locations, writing directions to cave entrances, and otherwise refining the quality of the locational information. CRF provides copies of the database to the park for reference uses. CRF also provides updated locational information for the park's GIS system.

### *Cave Survey and Cartography*

CRF coordinates volunteer cave location, survey, and cartography efforts within and around the Riverways. See following separate article.

### *Endangered Species Management*

CRF maintains a unified bat cave list for OZAR, with latest counts of major bat caves in the park and surrounding areas. For summer colony caves, CRF visits the caves in late summer in order to measure guano to obtain approximate counts and check on the health of the colonies. CRF personnel also participate in bi-annual winter bat counts with the NPS and Department of Conservation. CRF personnel also participated in meetings on developing strategies to deal with the White Nose Syndrome.

### *Educational and Cooperative Efforts*

CRF continued to work with the Pioneer Forest (largely located adjacent to NPS lands)

on cooperative cave management initiatives (gating, road closures, bat counts, signage, etc.) and participated in meetings with LAD Foundation (owners of Pioneer Forest) and Pioneer Forest personnel on cave management issues.

Members of CRF continue to help maintain the Powder Mill Research Center which enjoys constant use by researchers, cavers, and other volunteers. CRF members reviewed proposals and assisted researchers investigating: blind fish DNA, paleo-pollen in bat guano, and seismic-event indicators in caves.

Several environmental education tours of Round Spring Cavern were led by CRF members in 2008-2009; these were primarily for university classes in speleology and biology. CRF members Scott House and Mick Sutton helped lead a Southeast Missouri State University Cave Ecology field class working in OZAR caves for a week in spring 2008.

## Cave Research Foundation Student Research Grant Program

*George Crothers, Grant Program Chair*

Each academic year, the Cave Research Foundation (CRF) accepts proposals for graduate student research in cave and karst studies. Proposals may be in any field of the earth, natural, or social, sciences as long as the research addresses topics related to caves or karst. The Foundation may award up to \$10,000 annually, distributed among one or more grant recipients. Typically, awards range from \$1,000 to \$3,000. The truly exceptional proposal, which involves two or more scientific disciplines, may receive a Thomas C. Kane Memorial Award and up to an additional \$2,000 in grant support. Students must be enrolled in a degree-granting institution. Competition is open to U.S. and international institutions, but application materials must be in English. Research at either the Master's or Ph.D. level is eligible.

Following are abstracts of the research grants awarded for academic years 2008 and 2009:

In 2008, thirteen students submitted applications for research grants. Of these, four proposals were selected for funding. A total of \$7000 in grant funds was split among the recipients. Seven of the applications were from students in the geosciences, four were in the biosciences, and two were in archaeology. Applications were received from eleven different U.S. universities and two British universities. The grant applications are due in March of each year and consist of a proposal and budget, two letters of reference, and the applicant's curriculum vitae. Eight CRF members served as anonymous reviewers of the grant applications in 2008. Abstracts of the funded proposals may be found below. Recipients are asked to submit a brief summary of the project upon completion of their research, and three of the 2008 recipient's reports are also included in this Annual Report. Congratulations to the 2008 grant recipients. We hope to see their contributions to cave and karst research for many years to come.

*Meghan A. Rector (\$1500)*

*Department of Evolution, Ecology, and Organismal Biology, Ohio State University  
Living in an Extreme Environment: Effects on Web Properties and Species Interactions in the*

*Cave Spider *Meta ovalis* (Tetragnathidae, Araneae)*

*Abstract* – Cave ecosystems are often underrepresented in scientific research. Cave systems are a particularly harsh environment for most organisms since there is little light, low food availability, high relative humidity, and constant cold temperatures. These ecological stressors are increased within caves in comparison to surface environments, often resulting in behaviors and traits that are quite different than those of related surface species. Pigment loss and decreased metabolism are widely recognized as adaptive characteristics in cave-dwelling organisms. However, there are other traits that are less apparent. In the proposed project using the cave orb-weaver *Meta ovalis*, web architecture and silk material properties will be examined as potential adaptations to subterranean life. Preliminary investigations suggest that the spiders are utilizing silk with unique material properties, especially in response of fibers to relative humidity. Their silk behavior contrasts with that of all other known spiders, a possible adaptation to their subterranean lifestyle. This project investigates a new and unexplored adaptation to cave dwelling with implications for

comparative silk biomechanics and conservation efforts of these habitats.

*Amy Renee Smith (\$1500)*

*Department of Biology*

*,Portland State University*

*Mineral Weathering of Lava Tubes: Iron-Oxidizing Bacteria and the Search for Life on Mars*

*Abstract* – Iron oxidizers in cave environments are assumed to play an important role in mineral precipitation and the evolution of cave features, yet the underlying processes of microbial mineral weathering are poorly understood. Iron oxidizers may have the ability to accelerate the natural weathering of volcanic rocks due to their ability to alter the chemistry and solubility of iron-containing minerals. Furthermore, iron oxidizers may produce changes in the internal crystalline environment that are dissimilar to natural abiotic weathering patterns, which can be detected microscopically. Biogenic weathering features may represent trace fossils (or biosignatures) that are applicable to the search for life on Mars and the study of life on early Earth. Various weathering features such as etched pits, tunnels, microchannels, and galleries have been described in volcanic rocks of ancient and modern origin, although it is unknown whether certain features such as microchannels are indeed biogenic. Therefore, I propose to study the weathering patterns of isolated iron oxidizers that are produced on olivine crystals in the laboratory. Although cryophilic iron oxidizers have not yet been described, I am particularly interested in isolating this type of microorganism from lava tubes with permanent ice deposits. Ice-bearing lava tubes may host cryophilic iron-oxidizing communities that would be excellent analogs for life on Mars.

*Mark Tracy (\$1000)*

*Department of Geography and Geology,*

*Western Kentucky University*

*Impact of in-Cave Carbon Sources on the Evolution of the South Central Kentucky Karst Aquifer*

*Abstract* – Previous observations done by Anthony (1998) and Vaughan (1998) propose that a significant source of carbon dioxide may exist within interstitial fluids in sediment beneath active cave streams. The purpose of this research is to better understand the distribution of organic carbon in cave streams sediment, the degree that these form a source of CO<sub>2</sub>, and the overall degree to which this may influence karst aquifer evolution. This will be achieved by systematic geochemical analyses of interstitial fluids in cave stream sediments in different karst environments across the south central Kentucky karst aquifer. Special attention will be paid to the relationship between soil CO<sub>2</sub> levels and CO<sub>2</sub> levels within the interstitial fluids during the transition from the warmer summer months to the cooler winter months. If an in-cave source of CO<sub>2</sub> truly exists that is independent of soil CO<sub>2</sub> then in-cave CO<sub>2</sub> levels should remain relatively constant during the transition in seasons while soil CO<sub>2</sub> level should be high in the summer and low in the winter. This research will be an important step in better understanding carbon dynamics and aquifer evolution in warm, humid karst environments like those found throughout south central Kentucky and many parts of the world.

*Jack Wood (\$3000)*

*Department of Earth and*

*Environmental Sciences,*

*University of Illinois at Chicago*

*New Evidence for Speleogenesis ca. 50 to 18*

*ka from Porter Cave, Central Indiana:*

*Potential Glacial Hydrologic and Dynamic Controls*

*Abstract* – Questions remain on the role of hydrologic changes during Quaternary interglacial and glacial cycles on speleogenesis in mid-continent North America. There is limited evidence for direct glacial influence on karst development and speleogenesis, and if speleogenesis continues in ice proximal karst regions. The Northern Mitchell Plain, a karst plateau in central Indiana was subjected to glaciation during the Quaternary and hosted proglacial lakes. This study seeks to provide insight on hydrologic and glacier dynamic controls on karst development for the past 50 ka in central Indiana. Glacial lacustrine sedimentary sequences within Porter Cave and in the adjacent watershed indicate at least two significant rises in hydrologic base level at ca. 40 and 27 ka. Preliminary data suggests speleogenesis in the northern Mitchell Plain appears to be retarded during glacials, with higher and unstable base levels timed with the development of proglacial lake systems. Recent field studies support the hypothesis that the glacial conditions destabilize baselevel and inhibit speleogenesis. Large and rapid changes in baselevel and discharge resulting from ice-marginal oscillations, such as deglaciation, are associated with enhanced speleogenesis. Lake highstand outlets during the last deglaciation intersect karst conduits to form hanging springs. Subsequently, nick-point migration at the waterfalls is the principle mechanism for lowering of the cave floor since the last deglaciation. Millennial-scale resolution from proglacial lake sediments from recently identified cave and surface sections provides new data to further assess the role of the interglacial/glacial cycle on speleogenesis and cave development.

In 2009, eight complete grant applications were received. Of these, four were selected for funding at a total of \$8,500. Six applications were from students in the geosciences and two were in archaeology. Applications were received from seven U.S. universities and one Canadian university. The grant applications are due in March of each year and consist of a proposal and budget,

two letters of reference, and the applicant's curriculum vitae. Nine CRF members served as anonymous reviewers of the grant applications in 2009. Abstracts of the funded proposals may be found below. Recipients will be asked to submit a brief summary of the project upon completion of their research that will appear in a subsequent Annual Report. Congratulations to the 2009 grant recipients. We hope to see their contributions to cave and karst research for many years to come.

*Andrew J. Friedrich (\$2,500)*

*Department of Earth and Planetary Sciences,  
Washington University in St. Louis*

*Geochemistry of Ferromanganese Deposits in  
Pautler Cave, Southwestern Illinois Karst:  
Formation, Structure, and Influence on Trace  
Element Transport and Sequestration*

*Abstract* – Nano-crystalline iron (Fe) and manganese (Mn) oxides are ubiquitous in caves, and play a major role in controlling the fate and transport of numerous potentially toxic trace elements in karst aquifers. However, little is understood about the biogeochemical processes controlling the dissolution, transport, and precipitation of these minerals in karst systems or the mechanisms by which they sequester trace elements. Recent results indicate that Mn oxide coatings from cave stream pebbles, collected from caves in the southwestern Illinois karst, contain anomalously high concentrations of uranium (U). This discovery is interesting from an environmental point of view, but it also provides an opportunity to develop a unique U-series method for dating these coatings. Such a method could provide information about the time scales in which cave stream incision occurs if coated pebbles can be collected from various levels within a cave (e.g., in the present cave stream, in old upper dry passages). The objective of this study is to investigate the aqueous geochemical parameters controlling the source, transport, and formation of Fe and Mn oxide minerals in limestone caves.

Solid samples will be thoroughly characterized with numerous instrumental techniques. Geochemical modeling of the redox chemistry of the cave water will be used to explain the spatial distribution of Fe and Mn, and the energetics of possible microbial metabolic pathways responsible for Fe and Mn oxidation. In addition, the concentration and speciation of U in these deposits will be determined, which may provide necessary preliminary data to develop a geochronological method.

*Logan Kistler (\$1,500)*  
*Department of Anthropology*  
*Pennsylvania State University*  
*Ancient Plant DNA Analysis of the Prehistoric*  
*Eastern Chenopod*

*Abstract* – Previous research has revealed the importance of several crop plants cultivated in eastern North America beginning by about 5,000 calendar years before the present. Assemblages of archaeobotanical material from dry caves and rockshelters have been central to archaeologists' understanding of prehistoric subsistence in the area, including the importance of these domesticated plants during the Late Archaic and Early Woodland Periods. Although the importance of pre-maize agriculture is well established, it remains unclear where the cultivated plants were initially brought under domestication by humans. This study will use DNA analysis of modern and archaeological materials to better understand the origin of chenopod (*Chenopodium berlandieri* Moq.), one of the domesticated plants occurring frequently in caves and other archaeological sites in the Eastern Woodlands. Two competing hypotheses exist regarding the location of chenopod domestication. The eastern origin hypothesis suggests that chenopod was domesticated from a native species in the Eastern Woodlands, supporting eastern North America's status as an independent center of agricultural origin. Proponents of the competing Mesoamerican origin hypothesis argue that the prehistoric eastern

chenopod was derived from a Mexican variety that is still cultivated as a field crop today, and that was introduced to the Eastern Woodlands in prehistory. Comparison of ancient DNA sequence data with a diverse sample of modern wild and cultivated chenopods will allow the identification of the prehistoric chenopod's site of domestication.

*Katherine Knierim (\$2,000)*

*Department of Geology,*  
*University of Arkansas*

*The Use of Nitrogen and Carbon Stable*  
*Isotopes to Monitor Denitrification in the*  
*Karst Terrain of Northwestern Arkansas*

*Abstract* – Nitrate contamination in karst environments has the potential to negatively impact water quality because of the decreased purification capacity of karst rocks (Panno et al., 2001). Northwestern Arkansas is characterized by karst landscape and a large agriculture industry, which contributes to nitrate pollution of groundwater (Peterson et al., 2002). Denitrification is an important mechanism for removal of nitrate, but nutrient processing in karst landscapes is poorly understood (Peterson et al., 2002; Winston, 2003). To better quantify nutrient processing, the stable isotopic compositions of nitrate and nitrogen gas ( $\delta^{15}\text{N}$ ,  $\delta^{18}\text{O}$ ) and organic/inorganic carbon and gaseous carbon dioxide ( $\delta^{13}\text{C}$ ) will be monitored in a karst setting in northwestern Arkansas. To test the hypothesis that changes in these isotopic compositions of carbon and nitrate can be used to monitor denitrification, compounds labeled with heavy nitrogen and carbon isotopes will be added to the hydrologic system and measured along the groundwater flow path, from the soil, to a cave, to discharge at springs. This experiment will provide insight into how nutrients are processed in karst settings and, specifically, how cave environments are impacted by agricultural pollution.

*Peter J. van Hengstum (\$2,500)*

*Department of Earth Sciences*

*Dalhousie University, Canada*

***Developing a Combined Micropaleontological (Foraminifera) and Stable Light Isotopic ( $\delta^{13}\text{C}$ ,  $\delta^{18}\text{O}$ ) Approach for Reconstructing Flooded (Phreatic) Coastal Caves***

*Abstract* – Flooded (phreatic) coastal cave systems have a global distribution, provide an observation site for continental-oceanic subterranean circulation, host unique and endangered aquatic ecosystems, provided a refuge for early-Holocene hunter-gather human populations, are structurally and environmentally influenced through sea level change, and are currently threatened by groundwater pollution from coastal urbanization. Despite their inter-disciplinary importance, there is currently no developed proxy capable of monitoring or evaluating environmental evolution in phreatic caves—a significant research problem. Foraminifera have a wide reputation as coastal proxies, where researchers can apply paleoecology and the isotopic geochemical signals preserved in foraminifer shells (i.e., carbon, oxy-

gen) to reconstruct various environmental parameters (sea level change, salinity, organic matter fluxes, etc.). However, foraminiferal ecology and their paleoenvironmental utility have yet to be systematically evaluated in coastal phreatic caves. Based on multiple lines of global evidence, foraminifera are systematically colonizing phreatic caves and can address the problem. The goal of this research is to develop foraminifera as environmental proxies in phreatic coastal caves by (1) examining their modern ecology and isotopic geochemistry in caves, and (2) evaluating their long-term utility as proxies by investigating historical foraminifer distributions in phreatic cave sediments. This research is anticipated to: (A) provide basic ecological information of foraminifera in phreatic caves, (B) evaluate foraminifera as environmental proxies in phreatic caves, and (C) develop a multi-proxy (paleoecology and geochemistry) and interdisciplinary (earth, biological, and chemical sciences) approach for reconstructing long-term environmental changes (sea level oscillations, climatic shifts, hydrogeological changes, etc.) archived in global coastal caves.

## CAVE BOOKS

*Paul Steward*

In 1981, several cavers combined their money, knowledge, and their love of books to form CAVE BOOKS, a non-profit press devoted to the publishing of cave and karst related material. Who better to publish books about caves then cavers?

The first book was *The Grand Kentucky Junction*, a companion to *The Longest Cave*. Since that first book, CAVE BOOKS has gone on to become the largest publisher of cave and karst books in the world. We also publish CRF annual reports, newsletters, research monographs, historical reprints, and cave maps. Solicitation of manuscripts is an ongoing endeavor and new items are continuously being added to the inventory.

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Alpine Karst, 2004, Volume 1

Tina Oliphant, editor. 2004. Illustrated. 130 pp.

The Art of Caving

Linda Heslop. 1996. Illustrated. 50 pp.

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