

# Cave Research Foundation Annual Report 2010–2011





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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.

Cave Research Foundation 2010–2011 Annual Report  
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Front cover photo: Frogs in an Ozark National Scenic Riverways cave. Photo by Ed Klausner.  
Back cover photos: *top*, a rainbow over Lava Beds National Monument. Photo by Dave West. *Bottom*, CRF cavers in an Ozarks cave. Photo by Jim Cooley.

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For information contact  
Ed Klausner

1132 Hotz Avenue  
Iowa City, IA 52245

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## Officers, Directors, and Operations Areas

	<b>2010</b>	<b>2011</b>
<b>President</b>		
<i>Scott House</i>	<b>Directors</b>	<b>Directors</b>
<b>Vice President</b>	<i>George Crothers</i>	<i>George Crothers</i>
<i>Charles Fox</i>	<i>Charles Fox</i>	<i>Charles Fox</i>
<b>Treasurer</b>	<i>Joyce Hoffmaster</i>	<i>Joyce Hoffmaster</i>
<i>Robert Hoke</i>	<i>Ed Klausner</i>	<i>Ed Klausner</i>
<b>Secretary</b>	<i>John Lovaas</i>	<i>John Lovaas</i>
<i>Bern Szukalski</i>	<i>Steve Ormeroid</i>	<i>Kayla New</i>
<b>Science and Grants</b>	<i>Pat Seiser</i>	<i>Steve Ormeroid</i>
<i>George Crothers</i>	<i>Bern Szukalski</i>	<i>Bern Szukalski</i>
	<i>Diana Tomchick</i>	<i>Diana Tomchick</i>
<b>National Personnel Officer</b>	<b>Eastern Operations Area</b>	<b>Eastern Operations Area</b>
<i>Phil DiBlasi</i>	<i>Dave West</i>	<i>Dave West</i>
<b>Newsletter Editor</b>	<b>Sequoia/Kings Canyon and Mineral King Operations Area</b>	<b>Sequoia/Kings Canyon and Mineral King Operations Area</b>
<i>William Payne</i>	<i>John Tinsley</i>	<i>John Tinsley</i>
	<b>Hamilton Valley Operation</b>	<b>Hamilton Valley Operation</b>
	<i>Patricia Kambesis</i>	<i>Patricia Kambesis</i>
	<b>Lava Beds Operation Area</b>	<b>Lava Beds Operation Area</b>
	<i>Bruce Rogers/Pat Helton</i>	<i>John Tinsley</i>
	<b>Ozarks Operation Area</b>	<b>Ozarks Operation Area</b>
	<i>Mick Sutton</i>	<i>Mick Sutton</i>
	<b>Southwest Operations Area</b>	
	<i>Barbe Baker</i>	

## Cave Research Foundation Awards

The Cave Research Foundation awards Fellowship in the CRF to those CRF members who have made significant long-term contributions to the foundation. Individuals who have made significant contributions in a particular area are awarded Certificates of Merit. Both Fellowship and Merit awards are in appreciation of a member's efforts. The following people have received such recognition in 2010 and 2011:

### 2010 Fellows

*Jim Cooley (Ozarks)*  
*Roy Gold (Ozarks)*  
*Ben Miller (Ozarks)*  
*Tony Schmitt (Ozarks)*  
*Harry (Buz) Grover (Eastern)*  
*Matt Goska (Eastern)*  
*John Lovaas (Eastern)*  
*Dawn Ryan (Eastern)*  
*Elaine Garvey (Sequoia/Kings Canyon)*

### 2010 Certificates of Merit

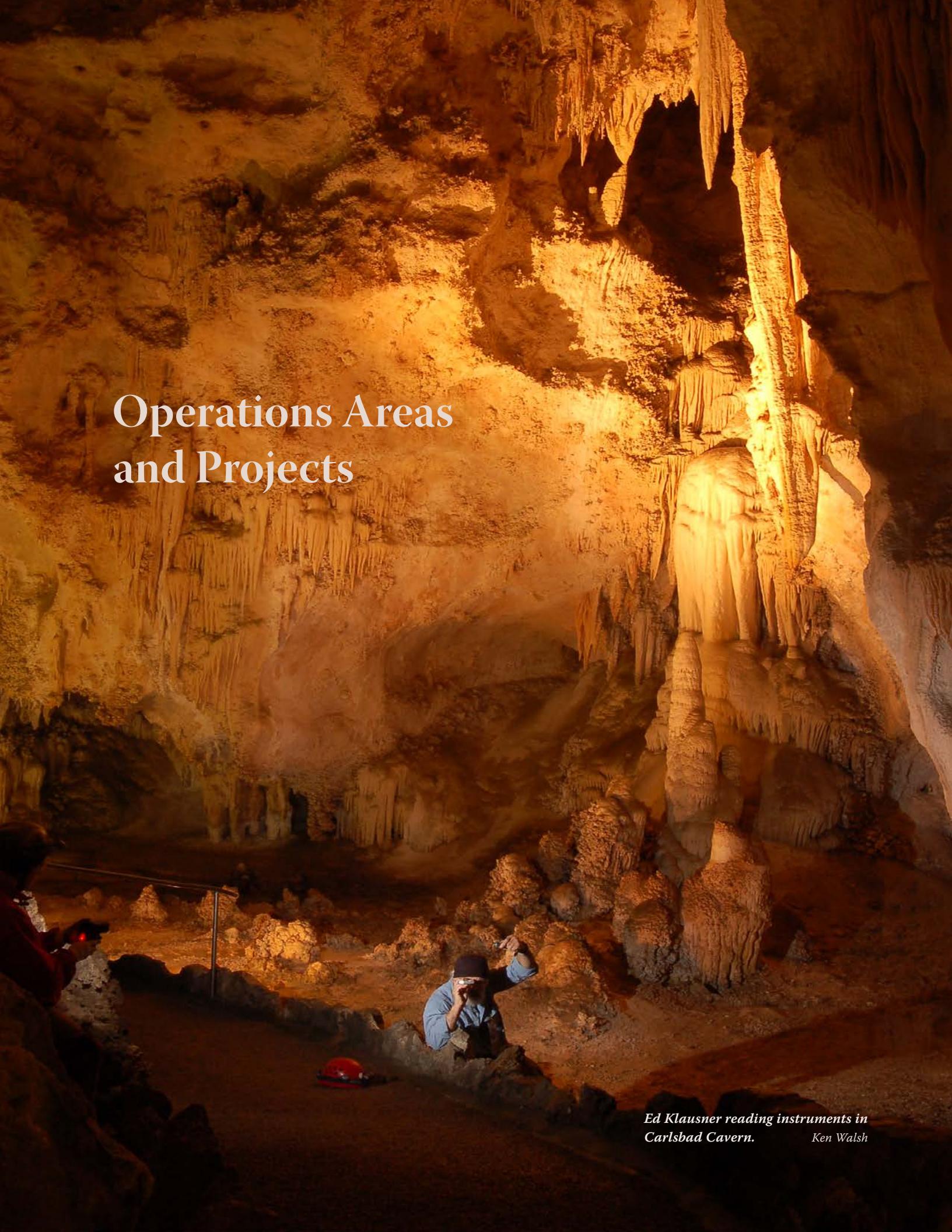
*Carolyn Johnson (Ozarks)*  
*Philip Johnson (Ozarks)*  
*Kayla New (Ozarks)*  
*Charley Young (Ozarks)*  
*John Feil (Eastern)*

### 2011 Fellows

*Rudolfo "Fofo" Gonzalez (Sequoia/Kings Canyon)*  
*Patti House (Ozarks)*  
*Laura Lexander (Eastern)*  
*Tammy Tucker (Carlsbad Caverns Project)*  
*William Tucker (Carlsbad Caverns Project)*

### 2011 Certificates of Merit

*Mark Scott (Sequoia/Kings Canyon)*  
*R. Scott House (Ozarks)*



# Operations Areas and Projects

*Ed Klausner reading instruments in  
Carlsbad Cavern.*  
Ken Walsh

## **Eastern Operations Area**

**Dave West**

*Area Manager, Eastern Operations*

### **October 1, 2009–September 30, 2010**

During this period, Eastern Operations at Mammoth Cave National Park fielded 142 parties, devoting over 14,408 hours to the park in support of various projects as follows:

#### **IN PARK**

- MCNP Cartography—121 parties
- Small Cave Inventory—11 parties
- Photo Documentation—3 parties
- Geology—2 parties
- Biology—2 parties

- History—3 parties
- Cave Art—4 parties
- Fish Research—1 party
- Park Requested Support—1 party

This year's work was again affected by White Nose Syndrome (WNS). 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.



*Rick Olson in Mammoth Cave.*

*Ed Klausner*

Many trips supported multiple objectives. Small Cave support continued with parties that worked in White Lightening Cave and Great Onyx Cave. In Mammoth Cave, fifty-three parties worked to complete all sheets for the main tourist routes, which continues to be a priority for the park. In other parts of the system, twenty-three parties worked in Unknown Cave, seven in Crystal Cave, eight in Salts Cave, twenty in Colossal Cave, and three in Proctor Cave. Support was also provided in Sanders Cave for fish research.

Eastern Operations ceased support for any work outside the park (Roppel, Hidden River, etc.) after the USF&W moratorium was announced, as no "sponsor" was available for it.

Gap Cave was looked upon as being at the gateway to the west for WNS but remains unaffected. The cave is now over 15.6 miles in length. Work has also begun on small caves there, with mapping of White Rock Pits number 1 and 2, and Cliff Cave, where work continues. In another cave found while searching for the White Rock Pits, Dweeb Cave, survey work was aborted due to bat activity.

## October 1, 2010–September 30, 2011

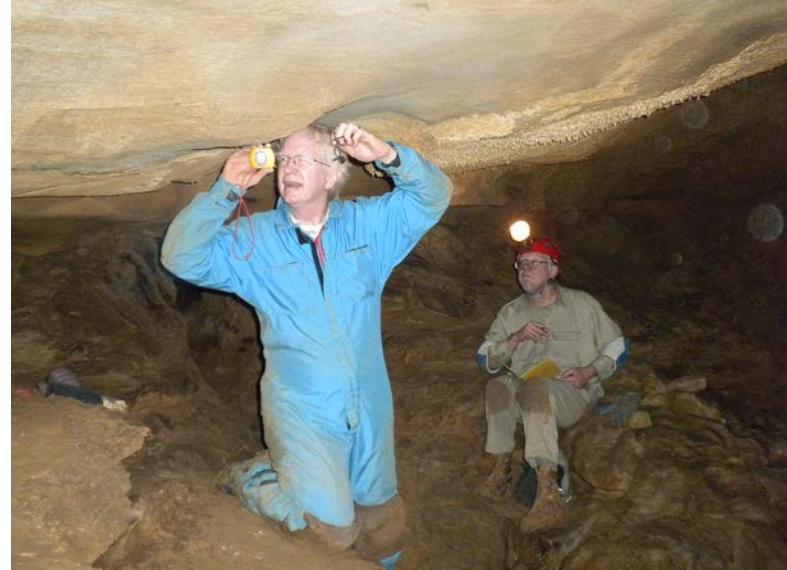
During this period, Eastern Operations at Mammoth Cave National Park fielded 126 parties, devoting over 11,720 hours to the park in support of various projects as follows:

### IN PARK

- MCNP Cartography—108 parties
- Small Cave Inventory—7 parties
- Geology—12 parties
- Biology—1 party
- History—2 parties
- Park Requested Support—7 parties

Work was resumed in Roppel Cave, and an additional 214 hours were worked there as well as in our own Adwell Cave. This year's work was still affected by White Nose Syndrome (WNS). 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 continue to refrain from work in known bat caves, but with WNS now in Kentucky and the surrounding states, we have renewed work in small caves. As requirements and guidelines change, we have adapted to meet the changes.

Many trips supported multiple objectives. The major accomplishment of the year was the connection of Donkey Cave into the system. Joyce Hoffmaster made the through trip into Unknown Cave during the Memorial Day expedition, but as she was the only one present that fit, it did not get surveyed until August. Wilson Hollow Pit was



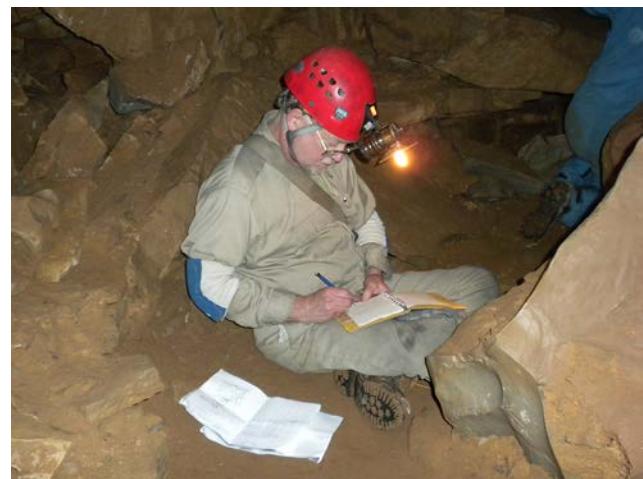
*Charles Fox and Scott House surveying in College Heights Avenue in Mammoth Cave.*

Ed Klausner



*Roger Brucker with light on station in College Heights Avenue in Mammoth Cave.*

Ed Klausner



*Scott House sketching in College Heights Avenue in Mammoth Cave.*

Ed Klausner

discovered and dropped, but it was dead bottom and did not provide the hoped for connection to Wilson Cave and a bypass to the bat colonies. It has its own colony of Rafinesque bats, so it is still an important find. One party did assist with the count in Wilson this year and determined that the colony of little brown bats were still in good health, although the number of Sodalis were down somewhat. Park-requested trips included the repair of the gate and trail restoration in Bedquilt Cave after severe flooding rearranged the entrance. We hauled lights in for a renovation project and assisted with two trips to replace a sampling pump in Proctor Cave. We also hosted a writer researching a book on extraordinary places.

Gap Cave was looked upon as being at the gateway to the west for WNS, but remains unaffected. The cave is now over 16 miles in length. Work continues on small caves as well.



*Rick Toomey in the lower level of the Labyrinth in Mammoth Cave.* Ed Klausner



*Teresa Kurtz and Karen Willmes in Belfry Avenue in Mammoth Cave.*

Ed Klausner

# Mammoth Cave Cartography

*Ed Klausner, Bob Osburn, and Aaron Addison*

Recent progress in Mammoth Cave cartography has been on two fronts: managing the survey data in four discrete datasets, and drafting maps.

Several years ago a decision was made to standardize the data reduction and management for Mammoth, and the program Walls (created by David Mckenzie) was selected. Most Mammoth cartographers had already adopted Walls and used it to manage the data sets for their map sheets as they had done in the past with a variety of programs including CML, SMAPS, COMPASS, etc. There has been a welcome surge of drafting for the past few years as will be described below, and as more adjoining sheets were drawn a major issue developed with edge matching and data sharing. Fixed stations had historically been used to hold the cave still at boundaries so it could be drawn, but this process became harder to manage as more data sets had to be maintained.

About two years ago it became obvious that the data had to be managed in chunks big enough to include the larger loops in a single data set, thus eliminating the need to set and maintain a large number of fixed points at boundaries. There are several natural breaks in the system corresponding mainly to the major connections that have occurred over the years. Flint Ridge and Mammoth Ridge are only connected at two points, only one passage currently connects Mammoth Ridge and Logsdon/Hawkins River, and one passage connects Logsdon/Hawkins River with Roppel. These connections provide natural divisions for the data, thus four data managers were needed. Jim Borden has long managed the Roppel data. Bob Osburn had maintained Logsdon/Hawkins River for many years and added in Proctor. Ed Klausner took over Mammoth Ridge and Spike Crews Flint Ridge.

These data managers have a number of tasks, only some of which they realized at the onset. First, the data all needed to be proofed and the format of header and command information standardized. Besides proofing for typos, cleaning up the data involves the tedious chore of going through each survey book and making sure the data are corrected for compass course corrections, or that the date is used to determine magnetic declination corrections, but not both. Surveys were graded based on how complete the survey information is. The ideal survey has duplicate (fore and back) readings on all compass and inclinometer readings, but many of the older surveys do not, and some contain no inclination information at all. A grading scheme was devised and employed. In addition, duplicate survey for

the same passages needs to be removed, both so an accurate survey net length can be generated, but also to prevent older replaced survey contributing to loop closures. Many of the older surveys were redone because the survey was suspect. Some older survey has to be retained even though replaced because some side passages may be tied to the old survey but not the newer replacement survey. In this case, the old survey must be noted and subtracted from the total length of the cave. When the total data screening process is completed, the length totals from each of the four blocks can be summed to provide an accurate length for the cave. This process won't be totally done until the entire cave is drawn because some mistakes will inevitably only be found during drafting. A major issue is that data managers do not know every passage in their area and sometimes they cannot as yet tell whether two survey lines close together comprise duplicates or simply passages at different levels.

Another major challenge has been sorting out the Mammoth data control points. Historically, the base control point set for Mammoth has been a USGS survey done by H.D.Walker in 1935–6. This set consists of 37 benchmarks at several entrances and inside the cave passages. These were reported in latitude/longitude values which were recalculated to UTM and to Mammoth Grid values. Other points had been acquired by transit and theodolite survey, recorded locations for other USGS bench marks and by GPS units of varying abilities. A simple rectangular data grid was used for the data based on a zero point at TT8W, a brass survey cap at the Carmichael entrance. Newer points were collected or were available in various Geographic or Projected coordinate systems and converted back to the Mammoth Grid. It became increasingly clear that we did not understand the conversion process well enough to be sure of data integrity, especially at levels required for control points. In 2008 a winter effort reacquired entrance coordinates for most of the Mammoth Cave entrances. It was ultimately decided that these were internally consistent and they alone would be used as control points. Further it was decided that CRF should shift all cave data to UTM Zone 16 coordinates in order to be on the same system as the National Park Service.

Since map sheets had already been established for most of the Mammoth system and in some cases the maps finished, or nearly finished, it was a requirement to maintain the sheet boundaries into the new coordinate system. This has been accomplished through the efforts of Aaron Addison. One significant side effect of moving

the sheet boundaries from the cave coordinate system to UTM coordinates was a slight rotation of the sheet layout. This leaves us faced with the choice of having our sheet boundaries not being parallel to the page when printed or of rotating the sheets to make the boundaries page parallel and having true north not (page parallel). The angle is small, approximately  $\frac{1}{4}$  degree, and we have chosen the latter not only for this reason but also because it allows the existing sheets to piece together more precisely when adjoining sheets are viewed together.

In addition, exciting progress was made in drafting maps. There were new cartographers for the system such as Jeff Bartlett who took on the Big Rift and Echo River maps and who has already produced a map of each, Lynn Brucker who took on a map segment in Mammoth Ridge now called Grunge Trail, and Bill Koerschner who took on East Salts. All have been busy organizing data and surveying.

Here's a brief update for each area:

## Mammoth Ridge

Jeff Bartlett took on the Echo River map sheet and took several survey trips to this area. One trip surveyed a 208-foot section that was missing from the dataset. A deep water section was added to the modern survey by using inflatable kayaks, inflatable rafts, and some pool toys to survey a 1,403-foot stretch. It made for amusing stories. An electronic fish finder was used to ascertain water depths throughout the passage. Efforts have also been made to include survey from a 1981 dive survey of Echo River Spring into River Hall. There was no sketch, but Jeff represented this on the map as a passage with indefinite walls to show the survey line. Besides the Echo River portion of the sheet, he has also drafted the Gothic Avenue section of the Echo River map sheet and is working on other passage on the map sheet.

Ed Klausner has drafted the Historic map and is currently caught up (everything surveyed is on the map) for a total of 11.7 miles. This included Dixon Cave which was also drafted on the same map to show the relationship to Houchins Narrows. Doug Baker's trail map was used for much of the tourist trail. Quite a bit of new survey has been done in the past two years. River Acheron branch of River Styx was discovered at the bottom of Procrastination Pit in Gallows Way by Rick Olson. This has added over 2,200 feet 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, it can be surveyed. The same is true for Robbins Run near Vanderbilt University Hall. A connection was surveyed between Carlos Way and River Styx which added about 750 feet of new survey. In all, there were 37 survey trips to the

Historic section in the last two years. The park requested a map showing the relationship between Dixon Cave and part of Mammoth (Houchins Narrows in particular). This has been produced by drafting Dixon Cave on the Historic sheet as 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 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.

There are two additional map sheets on Mammoth Ridge that are being drafted by Ed Klausner: Albert's Domes and Cleaveland Avenue West. Bill Steele, Diana Tomchick, and Will Harris confirmed in the cave that there was a blunder in the Walls data (compass shot was reversed). The two passages that are north of Albert's Domes have been redrawn to show the correct location. Some survey was done in Albert's Domes and this had been drafted on the map sheet.

The lower level of the Cleaveland Avenue West map sheet has been drafted now that the lower level passages (Stevenson, Opossum, Belfry, Mystic River, and the Mystic Tributaries) have been added to the Walls dataset. 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.

As noted above, Bob Osburn (and Aaron Addison) collected differential GPS readings of Mammoth Cave entrances and tied these to the survey net. Besides that, Bob is responsible for eleven map sheets. Work was done on several in Mammoth Ridge and in the River System.

Lynn Brucker has taken on the Grunge Trail map sheet and has had several trips there to replace survey and close loops. Aaron Addison continues to work on the surveys in the East Bransford and Cockelbur areas. There is little vertical control on older surveys in these areas and decisions will need to be made on how much survey to replace. There were two trips into Kentucky Avenue (Mick Sutton's map sheet). Howard Kalnitz took over the Bishop's Domes map sheet, and five survey trips were taken there to clear up some confusion in the old survey books.

Scott House is responsible for four map sheets, all on Mammoth Ridge: Main Cave, Chief City, Cathedral Domes, and Frozen Niagara. Eight trips were taken into these areas, primarily to Frozen Niagara.

Since Derek Bristol took over the Carlos Way map sheet, he made great progress with nine survey trips, much of it new survey. The original survey had no backsights and no



**Gypsum in Mammoth Cave.**

Ed Klausner

vertical control (no inclinometer shots) and needed to be redone to reduce the chance of a survey blunder plus gain vertical control.

Charles Fox began work on Roaring River, much of it below New Discovery. Four survey trips were taken. This area will eventually be broken up into several map sheets.

## Flint Ridge

Dave West continues to work on Bedquilt where he is closing loops and working on eliminating duplicate survey, but major loops remain to be closed before drafting can begin. Over thirty survey trips were taken into Bedquilt. Tom Brucker directed numerous trips to his area of responsibility, Colossal Cave.

Bill Koerschner has been taking many trips into East Salts and is getting the scans of the survey books so he can determine what needs to be done in this area. Five survey trips were taken to East Salts.

Art Palmer is working on resurveying areas of Crystal Cave. There are missing surveys that must be replaced, and Art estimates that there are a few thousand feet of new survey to be done, mainly in Left of the Trap and in

the Overlook and Skyhook areas. Seventeen survey trips were taken into Crystal Cave.

Mick Sutton is responsible for four Flint Ridge map sheets: Salts Cave, Mummy Valley, Gravel Avenue, and Indian Avenue. Fifteen survey trips were taken here, mostly to Salts and Mummy Valley.

Jeff (Spike) Crews is responsible for four map sheets on Flint Ridge: Turner Mather Avenue, Argo Junction, Hansen Lost River, and Illinois Avenue. Twenty-seven survey trips were taken here, including a multi-day camp trip.

Paul Hauck has the Pohl Avenue and Lehrberger Avenue map sheets, and seven survey trips were taken to Pohl Avenue.

Ten survey trips were taken to Donkey Cave and this cave was finally connected to the Mammoth System. Jim Greer continues to work on the Brucker Breakdown map sheet and numerous trips were fielded to this area.

## Proctor and the River System

Jeff Bartlett has drafted the Big Rift map after 10 survey trips 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. They left permanent stations at each lead. One especially gullible team (led by Jeff) carried a four-piece sectional ladder in order to check high leads. They were rewarded with a minor breakout. Subsequent surveys above the chert beds have pushed the survey line upward into the only known upper level in the region. It is a series of canyons and tubes that so far has resulted in 3,000 feet of virgin cave. Many exciting leads remain and Jeff is always looking for survey crews.

Four other trips were taken to Proctor Cave (Pat Kambeisis is the cartographer) plus one to Hawkins River (Pat is the cartographer for this map sheet as well).

## Roppel

Work on Roppel Cave during CRF expeditions has stopped due to White Nose Syndrome issues. Before that, Ed Klausner took several resurvey trips to fix problems with the Walls dataset maintained by Jim Border. Many errors were fixed and much of the South Downey Avenue sheet has been drafted. Future work will depend on trips being able to go to Roppel during CRF expeditions.

# The Labyrinth of Mammoth Cave

Ed Klausner

This is a fairly typical story; a new cartographer gets an area to map, lots of new passage is added, the new map looks nothing like the old map.

Franklyn Gorin, owner of Mammoth Cave, claimed discovery of the Labyrinth in September of 1838. It was named after the Labyrinth in Greek Mythology. Mick Sutton and Sue Hagan's Mammoth Cave Gazetteer describes some of the early references to the Labyrinth, such as the 1845 Bullit description where ladders and a bridge were built to aid tourists.

The last time anyone worked in the Labyrinth was 12 years prior to the recent trips that expanded the mapped section. Figure 1 shows a section of the Labyrinth with an intriguing lead in the lower right. The problem was that there was one obstacle, a pit at survey station M10 with a precarious rock that didn't seem to be a good handhold. Previous trip reports described the obstacle. Obviously, this section of Mammoth Cave needed attention.

In 2010, Dave West, Karen Willmes, Shannon Mathey, and Alex Siefert took a trip to M10 to assess what would

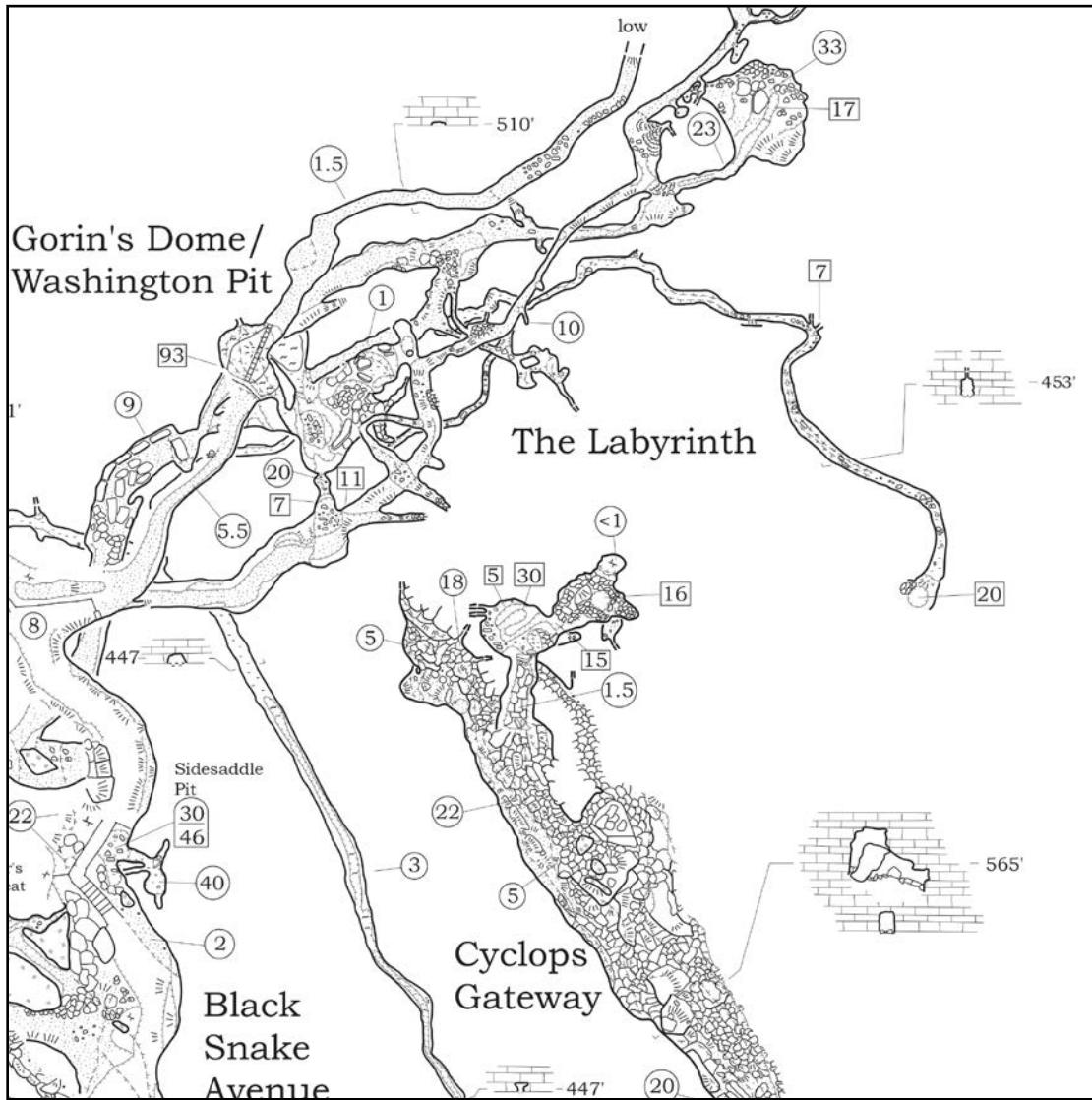


Figure 1.

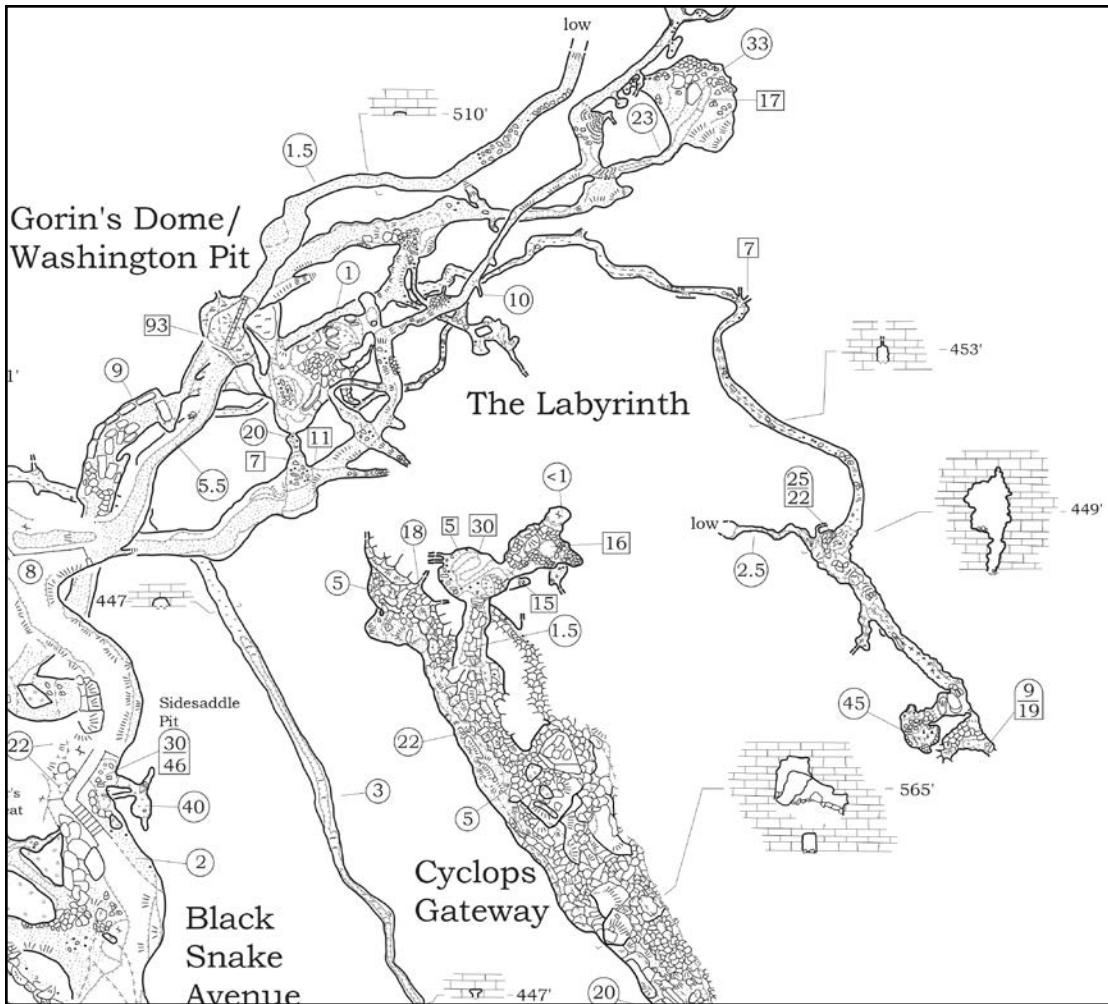


Figure 2.

be needed to cross it safely. Dave spent a considerable amount of time figuring out how to construct a bridge across the pit. A list of materials was assembled and we had plans to purchase them in Kentucky before an expedition. Meanwhile, Dave's neighbor was doing some work on his house and was using a scaffold with a nice wooden plank. Dave discussed the plank with his neighbor and pretty soon was driving to Kentucky with a plank on top of his van, a gift from his neighbor.

On November 25, 2010, Dave, Rick Toomey, Henry Grover, Elizabeth Miller, John Donahue, Bob Lodge, and I carried the plank into Mammoth Cave and maneuvered it around and down, into a lower level of the Labyrinth. Dave was the first to reach the pit and had the new bridge in place before the rest of the crew even arrived at M10. The bridge was a success and we were quickly across it to continue the survey.

The pit at the lower right of Figure 1 was our first objective even though we passed known leads along the way.

The pit was easily circumvented by going around the right side and that led to two easy areas to survey. Fortunately, two survey teams were available. Dave West took Rick Toomey and Henry Grover to survey the northern portion and I took Elizabeth Miller, John Donahue, and Bob Lodge to work on the large passage leading south, away from the pit. Both teams were disappointed. Dave's team completely surveyed the northern section for approximately 95 feet, and my team found that the large passage quickly degraded into a belly crawl with a few leads and about 150 feet of new survey. One of those leads led to another pit with some obvious passage on the other side.

While waiting for us, Rick Toomey and Dave West found a way to the bottom of the first pit and said that there was passage on the bottom. Good news, even more leads.

At the end of the first day, the map looked a bit more complex. See Figure 2.

A month later, Elizabeth, Aly Signorelli, Mandy Harris, and I returned to the pit that Rick Toomey and Dave West

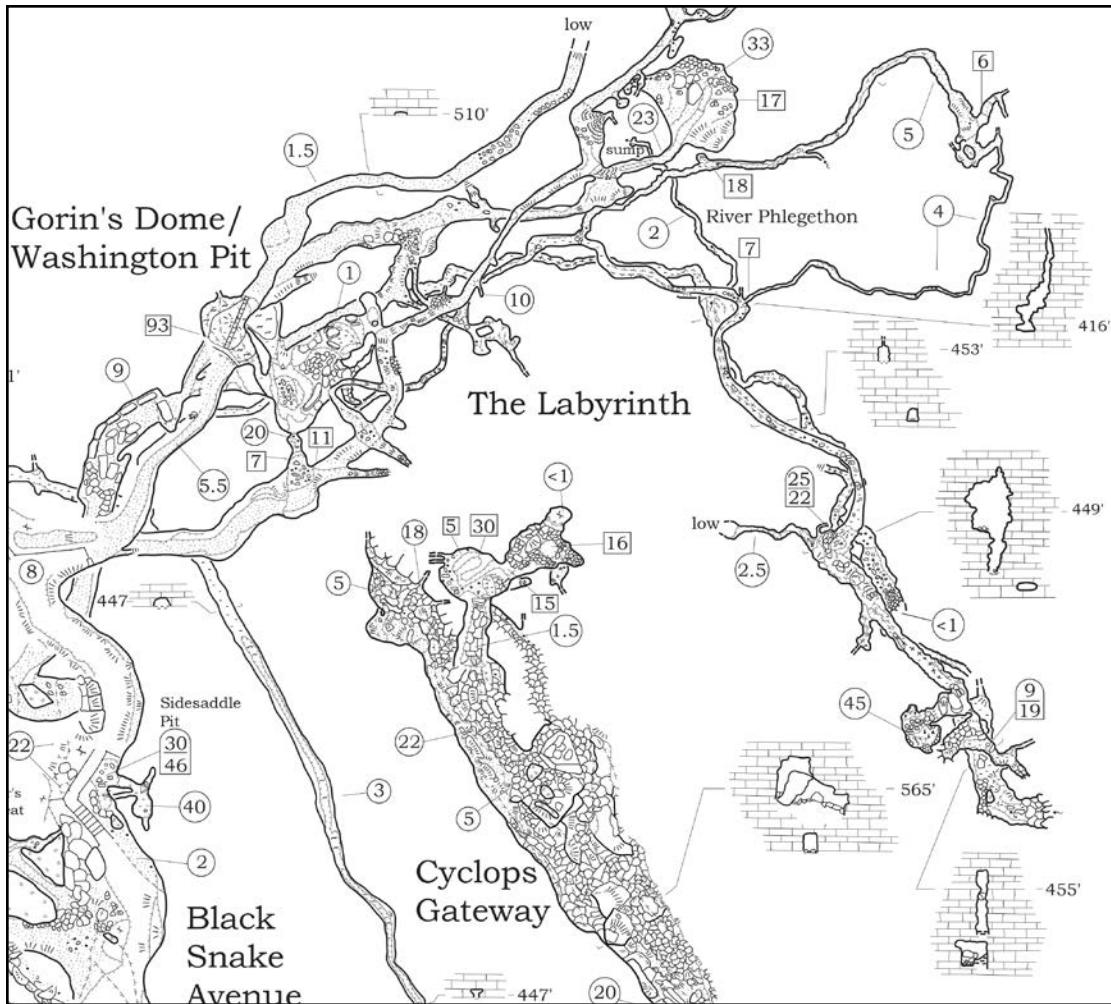


Figure 3.

had investigated the month before. In short order, we found a stream passage heading north, away from Gorin's Dome/ Washington Pit. We surveyed part of this passage, later called River Phlegethon. In subsequent trips, Rick Olson, Mark Jones, and I pushed this passage to a sump.

Many more people were involved and subsequent trips kept on adding passage, all in the same small area. Elizabeth Winkler sketched a good part of a long loop that we were all glad to finish, as it wasn't especially roomy.

Rick Olson, Rick Toomey, and I descended to the bottom of another pit only to discover more passage and more leads. Two of those leads will need a deer stand ladder to reach. The advantage of the deer stand ladder is that it can be carried in sections and is relatively lightweight.

This is not the only section of the Labyrinth to be expanded. Just north of Ariadne's Grotto (just north of what is shown in the figures), there is a small hole in the floor.

Karen Willmes, Elizabeth Miller, Brandi Zinn, and I surveyed a tight canyon heading south. The passage continues, and there are some holes in the floor that will need vertical gear. At the far north, there is a passage that is a water crawl. Tim Green, Nicole Bull, and I surveyed to an obstruction. Karen Willmes searched the old trip reports and found that there are a series of domes past this obstruction, and there were additional leads. Unfortunately, the notes for the domes were lost, and this will have to be resurveyed. The nice part is that this won't simply be a resurvey trip because the noted leads were never surveyed. Bob Osburn reported a substantial side passage in the lower levels of the Labyrinth. This, too, is on the lead list for future survey.

As of this writing, the Labyrinth appears as in Figure 3. It is aptly named and the map is likely to change. As stated above, this is fairly typical and this story has been repeated in many sections of Mammoth Cave and elsewhere.

# Cultural Resources Survey at Cumberland Gap

FY2010 Activities

*Charles Finney*

Date	Target	Team	Time	Report	*
2009-11-28	Gap Cave—Soldiers entrance, '1776 passage'	3	18.0	2009-12-13	A
2010-01-02	Gap Cave—Anteroom and Big (Coke Bottle) Room	3	18.0	2010-01-03	A
2010-02-27	Ridge walking	3	18.0	2010-02-28	A
2010-03-27	Ridge walking	3	18.0	2010-03-28	A
2010-04-24	Gap Cave—Big (Coke Bottle) Room	5	30.0	2010-04-25	A
2010-05-29	Big Salt entrance and Cliff Cave entrance	3	17.1	2010-05-30	A
2010-06-26	Cliff Cave	1	6.0	2010-06-27	A
2010-07-24	Cliff Cave	2	10.0	2010-07-25	A
2010-08-28	Ridge walking	1	5.0	2010-08-30	A
2010-09-03	Ridge walking	3	18.0	2010-09-04	A

**Team** refers to team size, in participants; **Time** refers to total person-hours in cave.

\* Report status is denoted by A for Activity Report or R for Research Report

The Cultural Resources Inventory team made 10 trips involving 99.1 person-hours in cave and 59.0 person-hours on the surface, for a total of 158.1 hours. The table summarizes the expeditions along with report dates.

Particular focus was placed on documenting evidence of Civil War and early-settler visitation and relating that to the known historical narrative of the cave and historical and pre-historical context of the local surroundings. Most of the cultural features documented were of the following types: signatures and related graffiti made by inscribing or marking rock surfaces with soot, charcoal, pencil or other dark or colored media; fragments or whole items made of clothing, wood, glass, metal, or other discarded anthropomorphic materials; clay or mud figures, and signs of disturbed soil related to foot traffic or excavations. As much as possible, each documented feature was located approximately (or in some cases precisely) relative to previously marked survey stations. In limited cases, no clear stations were found and cultural features were located in terms of other prominent landmarks (e.g., stairs or tourist trails). Photographs were made of each documented feature whenever possible.

Although not documented, considerable time (more than in-cave time) was also spent outside the cave researching historical records related to the documented items. These included extensive searches of military records, census records, newspaper files, library archives, and interviews with present and past local residents.

Highlights for each trip:

November 28: The '1776 passage' in Gap Cave and the near-entrance area of Soldiers Entrance were examined, with particular focus on the Antebellum and Civil War periods. Several prominent incised signatures were the targets of—unsuccessful—attempts at paper and charcoal rubbings, and all objects were photographed. Several prominent signatures of early settlers and many signatures of Civil War soldiers were documented.

January 2: The Dance Floor, Anteroom, and Big (Coke Bottle) Room, along with connecting passages were examined for historical signatures. A greater number and quality of signatures, particularly from the Civil War period, were noted, as well as instances of inadvertent damage to as well as natural degradation of certain signatures.

February 27: Areas around Lewis Hollow were examined for possible cave entrances, other karst features, and evidence of winter bat activity. Locations of all features were reported to the National Park Service.

March 27: Areas around Lewis Hollow were examined for possible cave entrances, other karst features, and evidence of winter bat activity. Locations of all features were reported to the National Park Service.

April 24: Many signatures in the Big (Coke Bottle) Room were documented using regular and enhanced photographic techniques. Of particular note were a series of signatures spanning 30 years with letters formed by rolled

cylinders of nearby mud; signatures of several well-known local residents were identified.

May 29: Several clear inscribed signatures from the Antebellum and Civil War periods were noted in the Big Salt entrance. The entrance to Cliff Cave was identified and marked for future study.

June 26: The CRS team followed the mapping survey team. Cliff Cave from the entrance to station CA5 was examined for historical visitation. Most evidence dated from the early-to-mid 20th century, with no evidence before the 20th century.

July 24: The CRS team followed the mapping survey team. Cliff Cave from station CA6 to CB7 and CC3 was examined for historical visitation. Most evidence dated from the early-to-mid 20th century, with no evidence before the 20th century.

August 28–29: Using a 1962 report by the Park Historian, cave entrances around White Rocks area near Ewing, Virginia were sought. A wide area was searched, with several karst features identified.

September 3: The objectives from the August 28 trip were continued, and three known cave entrances were found and marked.

The team continues evaluation of previously documented features and investigation of potential connections to historical records outside the cave. All significant findings are reported to the National Park Service.



*Mike Crockett outside Gap Cave.*

*Ed Klausner*

## California Operations Area

Reporting Period: October 1, 2010–September 30, 2011

California Operations at Sequoia and Kings Canyon National Parks (SEKI)

California Operations at Lava Beds National Monument (LABE)

***John C. Tinsley***

*Area Manager, California Operations*

### California Operations at SEKI

CRF-SEKI Ops conducts regular expeditions to Redwood Canyon and Mineral King, as well as to other SEKI karst areas as opportunities arise for project-related work. We convened an annual organizational meeting on January 8. We cancelled February, March, and April expeditions (winter storms) as California received about 150% of normal precipitation. Finally in early May, as snowdrifts slowly abated, our field season commenced in Redwood Canyon.

#### Redwood Canyon

Eight expeditions were conducted to Lilburn Cave in Redwood Canyon. Activities included cartography, structural geology, karst exploration, and support of Ben Tobin's and Jessica Oster's respective studies of the geochemistry of karst and epikarst waters respectively in Redwood Canyon. Except for the July 4 expedition, we were restricted to a head count of ten persons per expedition. Expeditions were generally fully booked, but suffered inevitable attrition because stuff happens. Attendance averaged 8 persons per expedition with five 2-day expeditions and three 3-day expeditions in 2011. A total of 152 person-days were invested on-site at 10 hours/day is 1520 hours. Travel to and from the Canyon to California's major metro areas demands a day per person each way, accounting for another 128 person-days.

#### Mineral King

There were two expeditions to the Mineral King area. Two other expeditions (Labor Day and Halloween weekend) were cancelled.

- August 13–14 (10 people)
  - Day 1: Tufa Spring to Eagle Sink ridgewalking in two teams, 9 am–6 pm (9 hour day)
  - White Chief Cave and Basin; touristing and ridgewalking, 9 am–3 pm (6 hour day)
  - total: 150 person-hours, trailhead to trailhead

- September 24–25 (10 people)

- White Chief area surveying and ridgewalking, four teams (10 people), 9 am–7pm (10 hour day)
- Tufa Falls Cave mapping (2 people), 9 am–3 pm (6 hour day)
- total: 112 person-hours, trailhead to trailhead

Present goals are to complete the White Chief Cave map this winter. Tinsley has the survey and penciled maps from Roger Mortimer and has completed most of the digital cartography. Some editing remains, and a couple of ambiguities remain to be resolved.

### California Operations at LABE

A new MOU was signed, ending a two-year hiatus in CRF project work at Lava Beds. CRF presently has 3 Research Projects (RPs) in place with LABE and 1 with Modoc National Forest:

- Cartography of Hardin Butte Area Caves (PI = S. House)
- Cartography of Cave Loop Caves (PI = L. Wolff)
- Photo-monitoring (PI = B. and P. Frantz)
- Cartography of Selected Modoc NF Caves (PI = W. Broeckel)

All LABE RPs were active in 2011 with at least two trips mounted in support of each PI. Wolff completed the Hercules–Juniper Leg map in pencil form; Tinsley scanned the map; digital scans are now in hands of Tinsley, Wolff, and Rogers. The map is to be rendered into digital form this winter by Bruce Rogers. In early June, Scott House imported himself and a doughty band of CRF folks from Back East and made a week-long stint in the surveys of Hardin Butte area caves. Team Frantz mounted two extended trips and has the photo-monitoring project rolling.

We had a Thanksgiving expedition with a Monday meeting scheduled in the AM with NPS management for further planning purposes. Folks arrived Friday and departed Sunday or Monday as their schedule permitted.

## Other Activities Supported by CRF Personnel during 2011

1. SpeleoEd Weekend at Sequoia NP (May 14–15)—CRF personnel gave talks, presented posters, and participated in all activities. The California Operations traditionally supports the NSS Regional activities by not scheduling expeditions opposite those dates.
2. Clough Cave Gating (Western Cave Conservancy organized this activity; there is much overlap among the cavers in California among various meritorious organizations.)

## New Developments in 2011–12

1. Samwel Cave Restoration, Shasta County, CA (October 29, 2011, and into 2012) (A joint activity with Shasta-Trinity NF, San Francisco Bay Chapter, Shasta Area Grotto, and independent NSS cavers not

affiliated with an NSS I/O). A recon trip was productive and showed the graffiti yields to basic water and scrubbing; the NF personnel are delighted to find that the cavers care. Sound prospects for future CRF work with Shasta-Trinity NF are likely to develop.

2. The SEKI project will evolve a lot in 2012, with a deliberate effort to move beyond our traditional activities and to undertake additional cartographic and inventory at other signature SEKI caves including Ursa Minor and Hurricane Crawl. There will be a significant effort to explore known blowing leads prior to a more restrictive digging policy anticipated to accompany the new cave management plan in a year or two. Funding for an Assistant Cave Management Technician has been lost, and this void creates a need that CRF is well-situated to assume. Active planning with the Cave Management staff is presently underway, and was rolled out during the organizational meeting in Fresno, California in January, 2012.



*Four Star-Ponderosa Arch*

*Dave West*

# Cave Loop Survey Project

Lava Beds National Monument

*Liz Wolff*

*Principal Investigator*

## 2010–2011

“Cave Loop” refers to an important cluster of lava tubes developed in the Mammoth Crater lava flow on Medicine Lake volcano, a shield-shaped volcano located west of the Cascades continental volcanic arc. The lava caves are accessed via paved road (Cave Loop Road) and within Lava Beds National Monument are the principal caving areas to which the National Park Service directs the public who come to tour the Monument’s more than 700 known caves. These caves are often complex and contain multiple levels and display a plethora of features that record the natural history of the region, its cultural history, as well as many aspects of lava flow processes. In the past 5000 years, Medicine Lake Volcano has had more eruptive activity than any volcano in the Cascades region, most recently about 1000 years ago (Donnelly-Nolan et. al. (2007).

The Cave Loop Survey Project was initiated following a rescue in 2004 from Catacombs Cave when the searchers were given incomplete maps to guide them. A survey project was initiated by the Monument for complete maps, including vertical information for each cave, and a better understanding of the spatial relations among the caves. Present protocols include taped distances, fore- and backsights agreeing within two degrees, clinometers agreeing within one half degree for each station, LRUDs for each station as well as intermediate LRUDs for greater detail in the sketch and finished map. While the compass and clinometer agreement seems to be a no-brainer, experienced surveyors in basaltic lava understand that the rock contains ferrous and ferric iron and magnetite to varying degrees; the effect of these localized non-dipole magnetic fields often makes perfect magnetic-based instrument agreement difficult at best. Owing to occurrences beyond our control, a hiatus in fieldwork occurred in 2010 while the CRF’s Memorandum of Understanding with the Monument was rewritten and signed.

The surveys in 2010–2011 are as follows:

1. The Hercules Leg/Juniper Cave survey was completed, representing nine trips in 2009 and four trips in 2011. Survey totaled 5670.8 feet in-cave, plus 428 feet of surface traverse to tie in the associated Twin Falls and Hercules Derringer caves, and to complete one entrance to entrance loop survey, for purposes of checking overall closure. Twin Falls Cave is 169 feet long, Hercules Derringer 34 feet long. Statistics: 18 trips; 27 cavers; 98 stations; 2646 man-hours; 16 loops; eight entrances. The Hercules Leg/Juniper Cave map is nearing completion.
2. Sentinel Cave has six distinct levels. The survey was nearly completed in 2009, with some dicey climbs remaining in order to survey uppermost levels of the Basement section of the cave. A survey from 1986 and a fairly comprehensive sketch from 1969 were used to add the upper levels of the Basement to the map. Survey totaled 4189.9 feet plus about 440 feet in the upper level Basement sketch, and 400 feet of surface traverse. Statistics: 24 trips; 31 cavers; 139 stations; 3720 man-hours; three loops plus one maze area; four entrances. The Sentinel Cave map is nearly completed.
3. For the years 2010–11 three cave surveys were completed; and the maps are in their final stages of being drafted.

## Reference Cited

Julie M. Donnelly-Nolan, Manuel Nathenson, Duane E. Champion, David W. Ramsey, Jacob B. Lowenstern, and John W. Ewert, 2007, Volcano Hazards Assessment for Medicine Lake Volcano, Northern California: U.S. Geological Survey, Scientific Investigations Report 2007-5174-A.

# Modoc National Forest Cave Survey Project

*Bill Broeckel*

*Principal Investigator*

## 2010

In Winter of 2010, details were still being added to Modoc National Forest CRF Report #6. This 82-page treatise covered ten Tickner chimney caves and summarized data from eight cave mapping trips involving six CRF joint venturers. Included were Judy Broeckel, Rebecca Broeckel, Bill Frantz, Beej Jorgenson, and Little John Woods coming all the way from Southern California. CRF supervision at that time came from Bill Devereaux, Pat Helton, Bruce Rogers, and Rich Steiger. Shane Fryer was the Lava Beds contact, and Patti Buettner was the contact with the Modoc National Forest.

With that report done, there was a pause in the project. Then on an expedition in May, there was time to do some scouting and GPS spot readings in two frontier areas. The first was at the leading exploration point out on the Valentine Flow with three caves identified: Decoy, Romancing the Stone, and Queen of Hearts Ice. In the other area, three more new caves appeared on the radar out by Dantes Tubs: Calico, an unnamed mammal den, and a large flower-pot with a cave-like covered edge. Also, an X cave showed up in a flow without known caves, but Ritual Cave stubbornly remained elusive, and help from the Forest Service will be needed to locate that reportedly abused cave, and to bring it into the fold of description.

Rhyolite Cave was tracked down on 8-10-10. This unusual cave is formed in rhyolite, a very sticky igneous rock that rarely forms caves. Unfortunately, it turned out to be located off the Modoc project, in another National Forest.

Some important work was done on a caving event 10-8-10 through 10-12-10. Russ Yoder, the man who has done extensive ridge walking over many lava flows, led a 10-8-10 trip that included two highly desirable cave locations needed for the Modoc project: Cracker Cave, and the rare and beautiful Enchanted Piper. 10-9-10 there was a visit to check ice levels in J.D. Howard's Glazier Cave. We found large, old ice masses substantially melted compared to previous visits, similar to recent findings in many other traditional ice caves in this region. 10-10-10 was a great

day. Senior CRF enthusiast Bill Devereaux walked us out to long lost La Boca Cave, a Modoc cave he had searched for and reported on previously. Not only was a key location obtained, but the cave was surveyed on the spot. It does have vertical entrances, but a completely horizontal through trip can be done using the smaller holes at the ends of the main passage. Matt Bowers was also on this trip, and very important groundwork was laid for Report #8. 10-11-10, Shane Fryer revealed a previously unknown Modoc cave zone in a very remote area. A long hike was needed, and there was only time to check a few of the multiple caves in this cluster. Two of the larger ones harbored bats. Shane had named another interesting one: Split Tongue Cave. 10-12-10 another new area was found near the Lava Beds border, with several small caves. To summarize: the project is not running short of material.

Isolated Yellowjacket Ice Cave was surveyed on 11-2-10.

## 2011

This year, Modoc National Forest made a priority request for information on the caves in a particular management planning area. CRF attention was thus focused on responding to this request in a timely fashion. But first, there was a chance to help the Missouri CRF cavers out at Four Star and Fifth Star Grotto on 6-7-11. I very much enjoy these chances to share field time with project cavers from other parts of the caving universe. On 8-22-11 and 10-11-11, the Modoc project got back on track with completed surveys of Roly Poly and Dusty Hole. Persons involved in the four caves of this group (two caves had previously been surveyed) were Russ Yoder, Jim Wolff, Liz Wolff, and Judy Broeckel. Once again, it was Russ Yoder who was responsible for the original ridge walking that brought these caves to light. Other caves are suspected to exist in the Yellowjacket Butte Lava Flow, including a mountain lion site no one is anxious to explore. The brush tends to be high and thick in these parts, but maybe . . . Russ?

## Lava Beds National Monument

*Scott House*

*Principal Investigator*

### North Castle Flow

A new approved research project, following up on previous CRF work, was initiated in June of 2011. The North Castle Flow lies generally to the north of Hardin Butte in a low-gradient flow. Previous CRF work focused on just Township and surrounding caves. The project was expanded to include additional areas of the flow. Thorough inventories accompanied cartographic surveys, photographs, and locations of newly-discovered features.

In 2011 the mapping of Corral Cave was completed. A new cave, Achilles Cave, plus an associated arch, were surveyed for a total of about 400 feet. Another new cave, Rock in Hole Cave, was also mapped for 300 feet. Crescent Moon Cave was relocated and surveyed for about 100 feet. White Tube Cave, a cave that had been located, but not described or surveyed, was mapped to about 500 feet. And lastly, one new cave that may have been previously identified but not surveyed, Muleshoe Cave, was mapped.



*Karen Willmes runs lead tape as Scott House sketches in Lower Sentinel Cave.*

*Patti House*

### I&M Priority Caves

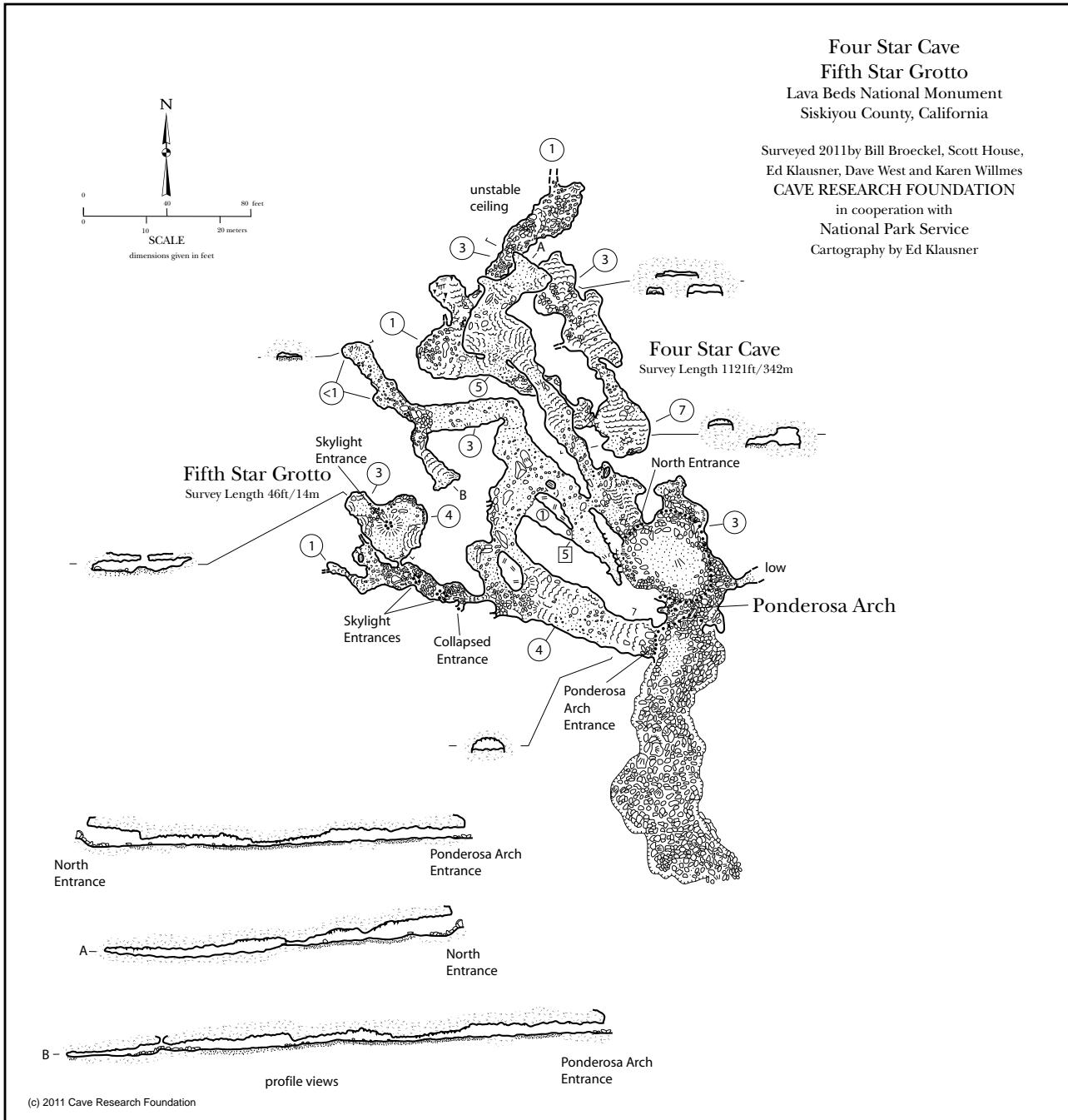
This project focuses on providing modern maps of several caves that are important to the NPS Inventory and Monitoring Network. Two caves were initially identified: Sentinel Annex Cave in the headquarters loop and Four Star Cave which is located in the Elmer's Trench area of the Monument. Both were completely surveyed. Future field work will begin by identifying additional priority caves for the NPS.

Participants in this year's expedition included: Scott and Patti House, Dave West and Karen Willmes, Ed Klausner, and Bill Broeckel.



*Scott House and Ed Klausner surveying at the entrance of Achilles Cave.*

*Patti House*



# Photo-monitoring in Lava Beds National Monument

[Permit LABE-2009-SCI-0006]

## *Peri and Bill Frantz*

In the early 1990s, Bill Frantz initiated a photo-monitoring project in Lava Beds National Monument by establishing monitoring sites in 16 caves and establishing protocols for taking reproducible photographs, with the intent that Monument staff would periodically re-shoot the photos and evaluate the results. In 2009, Bill and his wife, Peri, obtained a new research permit to bring the project into the digital age and also to assume responsibility for conducting periodic monitoring, which the Monument had been unable to sustain. After two productive trips in 2009, CRF activities were temporarily placed on hold, pending writing and signing of a new MOU with the Monument. The MOU was signed in May 2011, and work on this photo-monitoring project has resumed. Two photo-monitoring expeditions were conducted during the late summer and autumn of 2011.

## September 6–9, 2011

Bill and Peri Frantz, assisted by Jim and Liz Wolff, visited the monument during the week following Labor Day weekend. They met with Monument management personnel, conducted fieldwork, data management activities, and administrative activities, thereby re-establishing the photo-monitoring project. Principal field activities included relocating and re-shooting established stations in Arch, Catacombs, Hopkins Chocolate, Merrill Caves, and Valentine Caves. Two new stations were established in Shark's Mouth Cave, thereby adding this cave to the project's roster. A new photo-monitoring log form was tested and found to be quite workable.

A major focus of this trip was the reorganization of the photo-archive file structure and modification of file naming conventions in order to increase clarity and ease of use. Defective images from the earlier project were rescanned from the originals using a higher-quality scanner than was previously available. We have also begun rescanning images that were initially done at a relatively low

resolution. All new field notes, logs, maps, and site sketches generated on this trip were scanned and all newly obtained photographic images were uploaded to NPS archive files. Finally all NPS-related project data was synchronized with personal versions.

We met with LABE Physical Scientist Shane Fryer at the start of the expedition to discuss the relationship between CRF and the Monument, to review the status of the photo-monitoring project, and to identify a suite of current objectives and priorities. A final meeting with Mr. Fryer was held to review the progress made on this trip.

## November 25–28, 2011

On Thanksgiving weekend, Bill and Peri Frantz, assisted by John Tinsley, conducted the second photo-monitoring trip to LABE following the signing of the new CRF MOU last May. A suite of field activities, data management activities, and administrative meetings rounded out the weekend.

Field activities included re-shooting established stations in Golden Dome, Lost Pinnacle, and Juniper Caves. Only site #1 and site #2 in Lost Pinnacle Cave were reshot because site #3 is located in the crawlway that connects to the bat hibernaculum in Angieworm Cave. Given the low levels of visitation to this cave (we were the first and only party to sign the register since it was last maintained in August, 2010), and the proximity to the bats, we recommend that this station be dropped from the photo-monitoring protocol. Additionally, site #2 was extremely difficult to reframe, and does not adequately show the coralloids it is intended to monitor. This site should be reevaluated and possibly reframed. No issues were noted at the other photo-monitoring locations.

Data management activities included becoming familiar with the new laptop provided by Lava Beds Resources Management to be used to maintain synchronization between the CRF and LABE computer systems. We uploaded new photographs to the laptop but did not have time to

update logs, maps, etc. We also discovered inconsistencies between the LABE file system and our file system. Peri now has a copy of the LABE file system and will work at home to create a new, consistent image for transfer to LABE.

Administrative activities were again an important portion of the weekend. We met with Shane Fryer to discuss the status of the project, define objectives for this expedition and review all progress to date. We were privileged to

meet with Superintendent David F. Kruse, Shane Fryer, and others to discuss CRF Operations and project status and the likely scope of future activities. We also met informally with Chief Interpreter Terry Harris and discussed providing inputs to LABE-planned upgrades to the interpretive materials in Mushpot Cave and the potential re-deployment of the Virtual Valentine project at the Visitor Center.

## **Ice Level Monitoring in Lava Tubes**

Lava Beds National Monument

2010–2011

*Bill Devereaux and John Tinsley*

The Cave Research Foundation has conducted systematic measurements of ice levels in a dozen selected lava tubes of Lava Beds National Monument (LBNM) since 1990. This data set continues to be collected and maintained with measurements made in late spring and late autumn at times corresponding to seasonal maxima and minima of ice levels in most Monument caves. Occasionally, caves may be added or deleted from the monitored roster per the requirements of Resources Management, LBNM. All considered, these data afford a basis for making comparisons of long-term ice level changes and ice volumes there.

Measurements are typically made at established fixed reference points (usually two points, sometimes more) marked by a screw or pin inserted into the rock wall or ceiling above an ice floor. Using tapes, CRF personnel measure the distance from the reference pin to the ice floor. A decrease in the distance indicates positive ice accumulation; an increase indicates a net ice loss. Time-series analysis can be employed to learn if ice volume is accumulating or waning with time. This set of data is among the longer-lived sets of data at LBNM that has potential to shed light on effects of climate change in Monument lava tubes that preserve perennial ice deposits.

## Ozarks Operation

October 2009–September 2010

**Mick Sutton**

*Ozarks Operations Manager*

CRF Ozark Operations continued to be very active in FY 2010, with more than 40 field trips taking place despite restrictions to various programs owing to White Nose Syndrome (WNS) concerns.

*Geomycetes destructans* was identified from bats at several Missouri caves including a cave within Ozark National Scenic Riverways, one of our primary activity areas; however, there is an open question as to the validity of these identifications, and full-blown WNS has not so far appeared in Missouri. CRF continues to follow the situation closely and to offer advice and assistance to cave managers in devising policies to tackle the problem. Caves on the Mark Twain National Forest (MTNF) continue to be closed to the general public and were closed even to researchers and MTNF staff over the winter of 2010; however, this policy has been relaxed for the upcoming fall and winter season and CRF research programs are able to continue, albeit under tightly controlled conditions. Likewise, caves within Ozark National Scenic Riverways (ONSR) were subject to emergency near-total closure to the public immediately following the *G. destructans* finding but remain open to researchers for mapping, inventory, and monitoring. On the other hand, caves within the Missouri State Park system remain under total closure to any activity not directly WNS related. CRF crews assisted with bat monitoring and inventory in State Park caves over the winter, and we may be asked to assist in a similar effort over the coming winter.

CRF continues to collaborate closely with the Missouri Speleological Survey (MSS) and with individual NSS grottos, especially with regard to additions and refinements to the cave files. Almost all Ozarks Operations work results in additions and corrections to the detailed cave records maintained by MSS, and CRF President Scott House continues to act as curator of those records on behalf of MSS.

Buffalo National River, Arkansas continues to be a focus of activity not only in the form of mapping efforts at Fitton Cave, but also with increasing frequency within other caves of the Park. This effort has received a boost from Arkansas-based cavers led by Kayla New.

ONSR continues to account for a majority of CRF-Ozarks field trips. This enormously successful program, headed up by Scott House, resulted in the usual plethora of cave mapping, monitoring, and record keeping during



*Jeff Bartlett watches as Kayla New oozes out of a 9-inch squeeze in Copperhead Cave, Buffalo National River.*

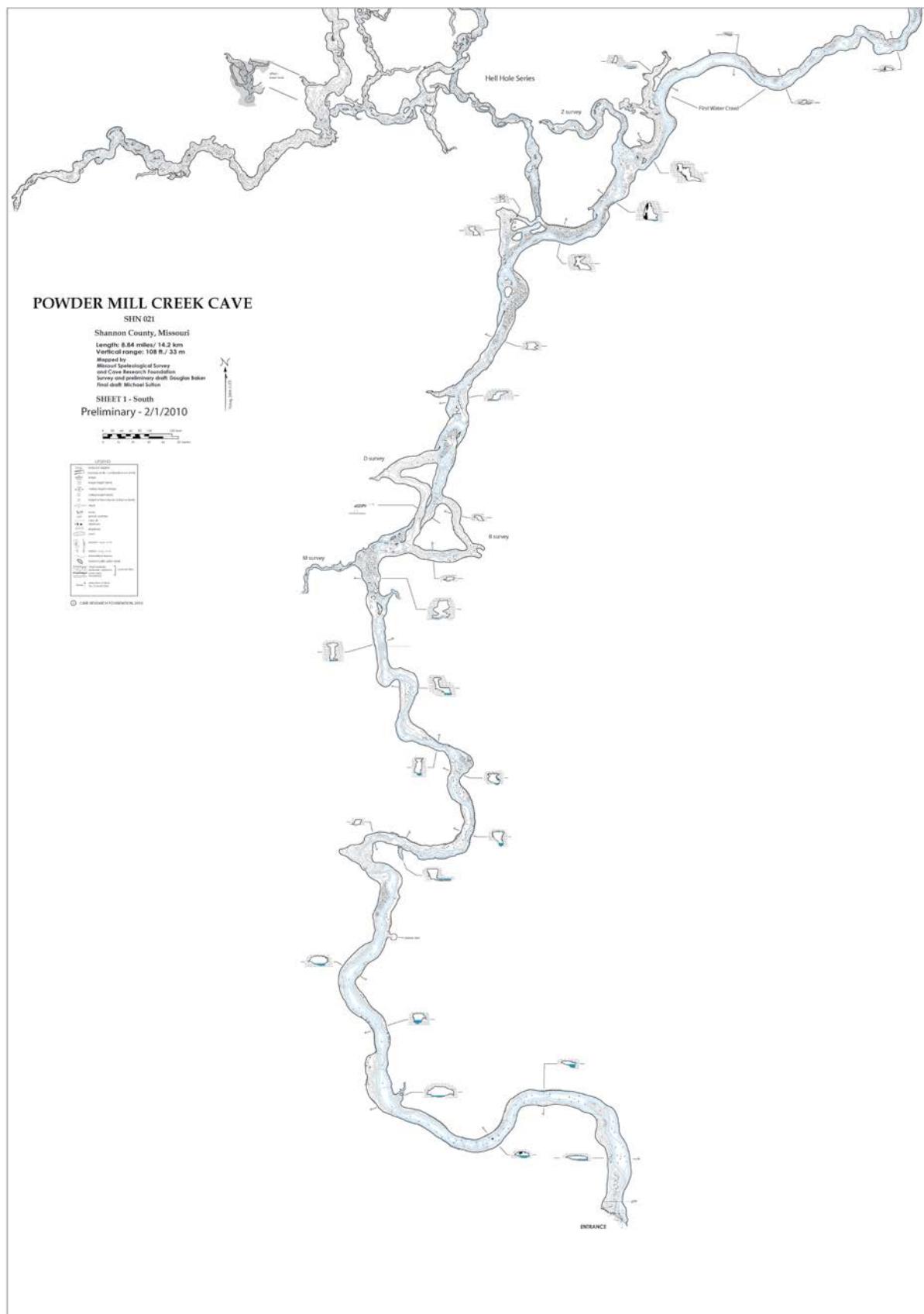
*Chad Holderfield*

FY2010 in addition to restoration activities including bat gate repair.

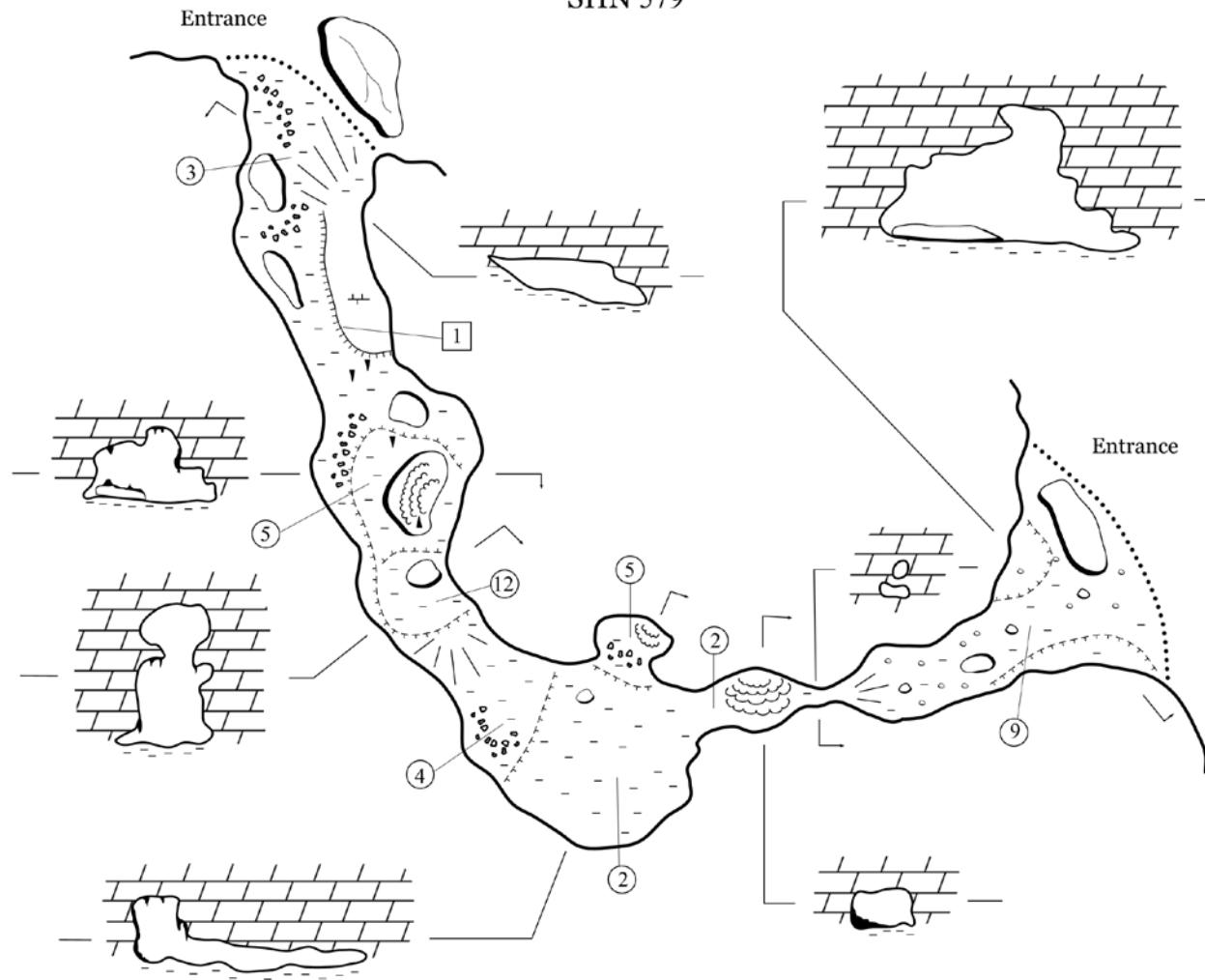
Highlights of activity on the MTNF included the discovery of numerous unrecorded caves, documentation of a new Indiana bat site, and construction of a 55-foot wide, 10-foot high bat gate at Kelly Hollow Cave. The latter effort, as well as most of the new activity within the Eleven Point District, was headed up by Jim Cooley. Much work continued on updating and digitizing MTNF cave records.

Activity with the State Park (Missouri Department of Natural Resources) system included, in addition to the bat cave inventory, a trip to assess the health of the famous pink planarian population in Devils Icebox Cave, where the system is slowly recovering from a severe crash in population. There was also extensive work on sorting out and digitizing DNR cave records.

Several unfunded Missouri Department of Conservation projects received work, notably the ongoing survey of a major stream cave which houses a gray bat colony, and the drafting of the Powder Mill Creek Cave map, a fairly major undertaking, with four map sheets eventually needed, the first of which is almost complete.

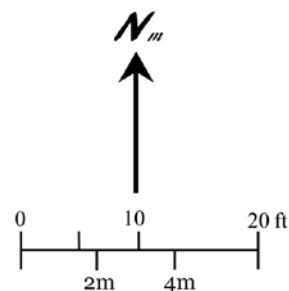


**Lucifuga Cave**  
Shannon County, Missouri  
Angeline Conservation Area  
SHN 579



Surveyed: June 20, 2007  
Surveyed by: Dan Lamping  
Steve Brandebura  
Surveyed Length: 108 ft  
Cartography: Dan Lamping

Cave Research Foundation in cooperation with  
Missouri Department of Conservation



All dimensions expressed in feet and drawn to scale  
Compass, clinometer and tape survey

## Ozarks Operation

October 2010–September 2011

*Scott House and Mick Sutton*

CRF Ozark Operations continued to be very active in 2010 and 2011, with even more field trips than ever, despite WNS-related restrictions. The approximate breakdown of field trip days by project is as follows:

- Ozark National Scenic Riverways cave management, survey, and inventory—81
- Mark Twain National Forest gating, survey, and inventory—107
- Buffalo National River cave survey and inventory—78
- Bass Pro project—2
- Berome Moore Cave survey—6
- Pioneer Forest inventory and survey—3
- Missouri State Parks inventory and survey—7
- Missouri Department of Conservation survey and inventory—6

There is some overlap in projects between field trips, resulting in a total of 274 field trip days during 2010 and 2011. The field time alone amounted to approximately 7,100 hours. At a modest volunteer rate of \$18/hour, that equals a value of over \$120,000 in skilled, professional service. And that is without counting the other expenses: more than 100,000 miles driven to and from projects, the person-hours involved in driving, drafting time, time spent

writing cave reports, or the subsistence cost of 870 people-days in the field, very little of which was reimbursable.

The situation with White Nose Syndrome remained a large concern as it has now spread to Missouri. CRF continues to follow the situation closely and to offer advice and assistance to cave managers. In general, caves on public lands remain closed to the general public and open to researchers with considerable safeguards.

## Buffalo National River

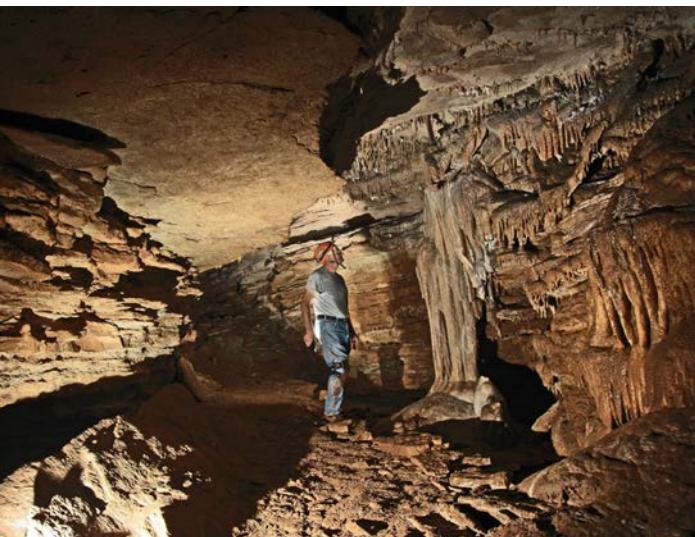
Added emphasis on watching out for WNS while also establishing baseline biological data made monitoring caves a high priority for the park. At the same time, cartographic surveys were made of a number of these that had never had a map. Most of CRF's fieldwork has been done on the Upper District, owing to the convenience of the Steel Creek research facility. Most expeditions are led by project leader Kayla New.

Several caves were surveyed in the Indian Creek canyon, a difficult field area to work in. Several maps were begun in Lost Valley, a rugged landscape of incredible karst: a good start was made on new maps of Cob Cave, a huge shelter cave, Lost Valley Natural Bridge, and Eden Falls Cave. Not far away, really high on the mountain, several trips were taken to Novak Spring Cave, a maze-like wet cave of none-too-spacious dimensions. In addition, numerous trips were taken to George Ridge in an effort to straighten out and survey the numerous caves located there. Also near to Steel Creek, several small pit caves were surveyed on the northern end of Shiloh Mountain.

Numerous trips were taken to Copperhead Cave, a mile-long stream cave. Before WNS closures this was a popular recreational cave.

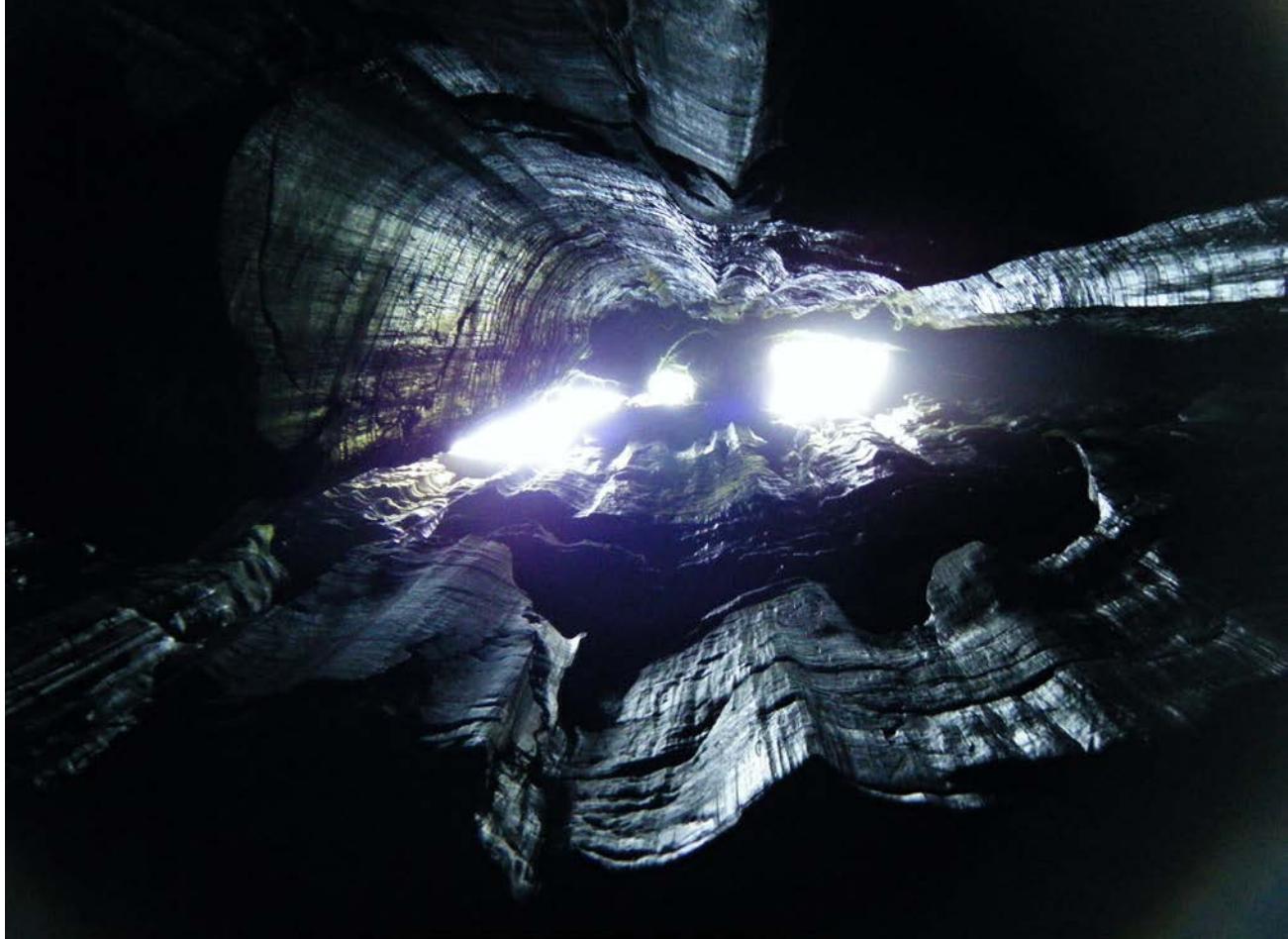
Much work was done in the general Cecil Cove area. Near Fitton Cave, several small caves in Bartlett Cove, a major tributary of Cecil Creek, were surveyed. New surveys of three well-known caves along Cecil Creek were initiated: Willis Cave, Mud Cave, and IceBox Cave. Several more caves were surveyed and monitored on the extreme headwaters of Cecil Creek. Meanwhile some survey was done in Fitton Cave along with a several-mile survey of bat populations.

Lower on the Buffalo River, a survey of popular Back o' Beyond Cave was begun.



*Charley Young in Back o' Beyond Cave, Buffalo National River.*

*Roy Gold*



*Looking out of Howling Dog Pit, Buffalo National River.*

*Andy Free*

Cave data work, focusing on the new cave database, occupied a group for several days. This is a long-term project; work was done at Steel Creek in order to access park files.

Most of the trips led into the park were for cave management issues, including restoration, monitoring, gate maintenance, and sign installation. CRF performs the bulk of this “grunt” work in the park, which results in the park having some of the most consistent cave management

## Ozark National Scenic Riverways

ONSR projects account for a high proportion of CRF-Ozarks field trips; this is made possible by a contract for cave management services including data acquisition. This highly successful program, headed up by Scott House, resulted in the usual plethora of cave mapping, monitoring and record keeping. Trips involved large numbers of CRF members, especially including one annual meeting and national expedition of the Foundation. One of the surveying highlights was the continuing survey of Bealert Blowing Spring Cave, which is turning out to have rather large amounts of wet, previously un-entered passage. Several other wet caves were surveyed including Akers Spring Cave and Ditch Cave. Surveying began in Alphen Hollow Spring Cave, which is turning into a long affair as well, and in Sluiceway Cave. Most of the wet surveys are on expeditions led by Dan Lamping. Survey was also completed on a new map of Branson Cave, a historic cave that CRF gated a few years past. One newly discovered cave, known in the distant past, was quite interesting being totally dry with some gypsum formations, a rarity in the Missouri Ozarks.



*A rare case of gypsum in the Missouri Ozarks. Scott House*



*Jeff Crews looks for aquatic life while monitoring caves in Ozark National Scenic Riverways.*

anywhere. CRF also participated in Junior Ranger Days (a school day) and provided leadership for college class trips into Round Spring Cave.

Otherwise, CRF helps maintain the Powder Mill Research Center, which we stage our expeditions out of; we also keep our cave gating materials at that locale. NPS support includes the research center, office space, cave equipment, computers, and all utilities.

## Mark Twain National Forest

CRF operates on the Forest through a cooperative agreement. Much of the work focused on cave resources in the Eleven Point District, along the Eleven Point River and including the Irish Wilderness. Numerous field trips, mostly organized and/or led by Jim Cooley and Mick Sutton, resulted in a number of new cave locations, reports, maps, and biological inventories. Kelly Hollow Cave was gated to protect the resources, including endangered bats, of this 6,500 foot long cave. The gate was a huge undertaking, being 55 feet wide and 10 feet high and located in a very remote area.

In southwest Missouri, efforts also continued in the Ava District where several mapping projects continued, including Bald Knobber Cave, mostly led by Eric Hertzler and Jon Beard. Two expeditions led by Jim Cooley ventured into the Piney Creek Wilderness of the Cassville District, relocating and mapping caves in that remote area. Additional cave maps and inventories were completed on the Willow Springs District, along the North Fork River, on trips led by Mick Sutton. One large cave map, Crocker Cave, was completed by Dan Lamping.

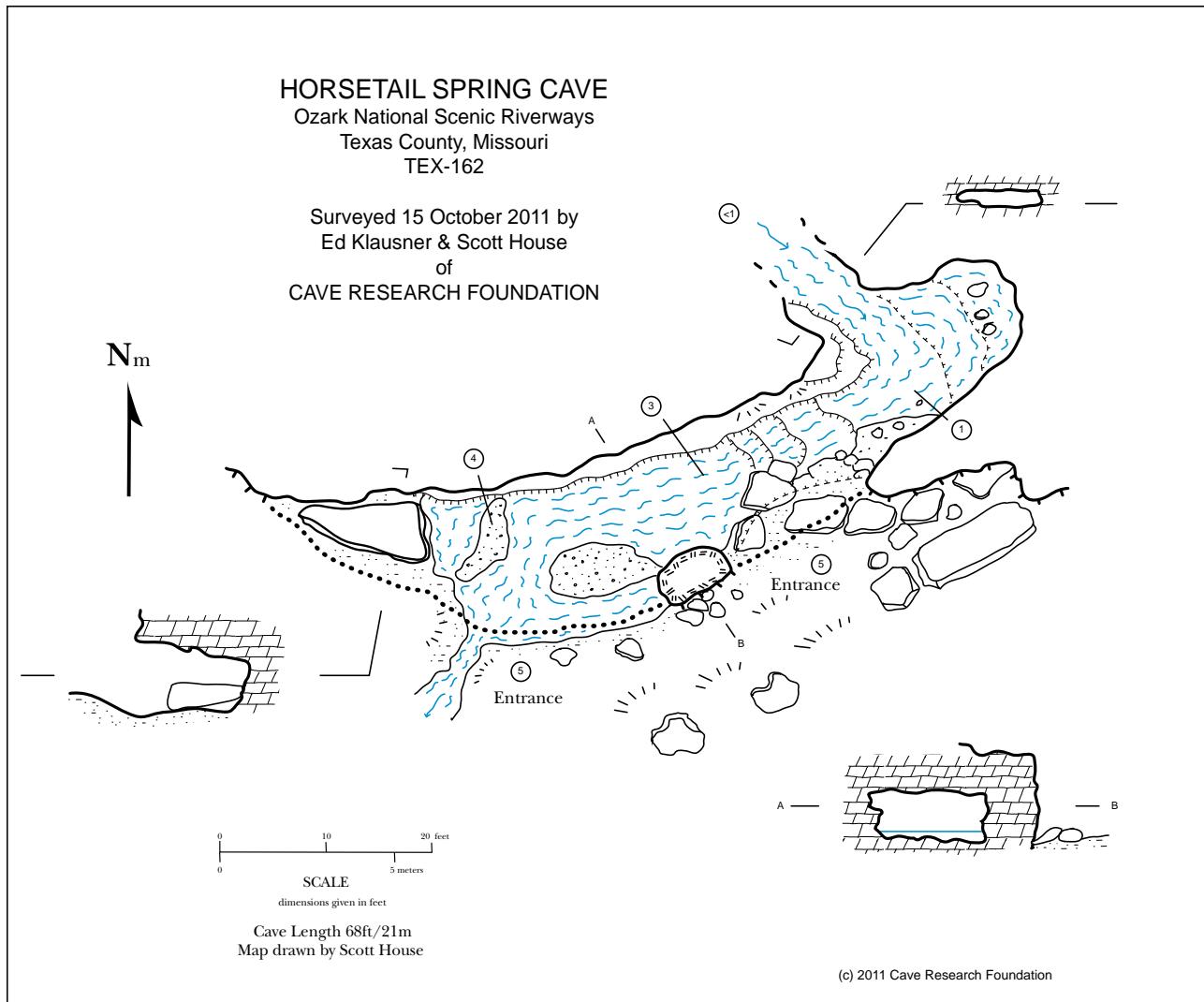
On the Houston-Rolla District, mapping was completed in White Pine Cave, an interesting and somewhat unusual cave for its location; other work, including monitoring of several cave archaeology sites, was also done. One expedition ventured into the Paddy Creek Wilderness where several high-priority caves were surveyed and inventoried.

Fieldwork on the Fredericktown District focused on a small cave area in the Rockpile Mountain Wilderness along the St. Francois River. On the Salem District surveys of two fairly large caves were completed: Bass Cave and Chimney Cave.

Our usual mapping, biological survey and monitoring activities on the MTNF were supplemented by an interesting



*A student dressed up as a caver at Junior Ranger Day, Ozark National Scenic Riverways.* *Scott House*



collaboration with archeologists Susie Jansen and Craig Williams from the Cave Archeology Inventory and Research Network. The CAIRN folks were able to bring an advanced technique—X-ray fluorescence elemental analysis—to bear on several archeologically rich caves. Much work continued on updating and digitizing MTNF cave records. There were several trips to do preliminary work, including archaeological assessments, for upcoming gating projects.

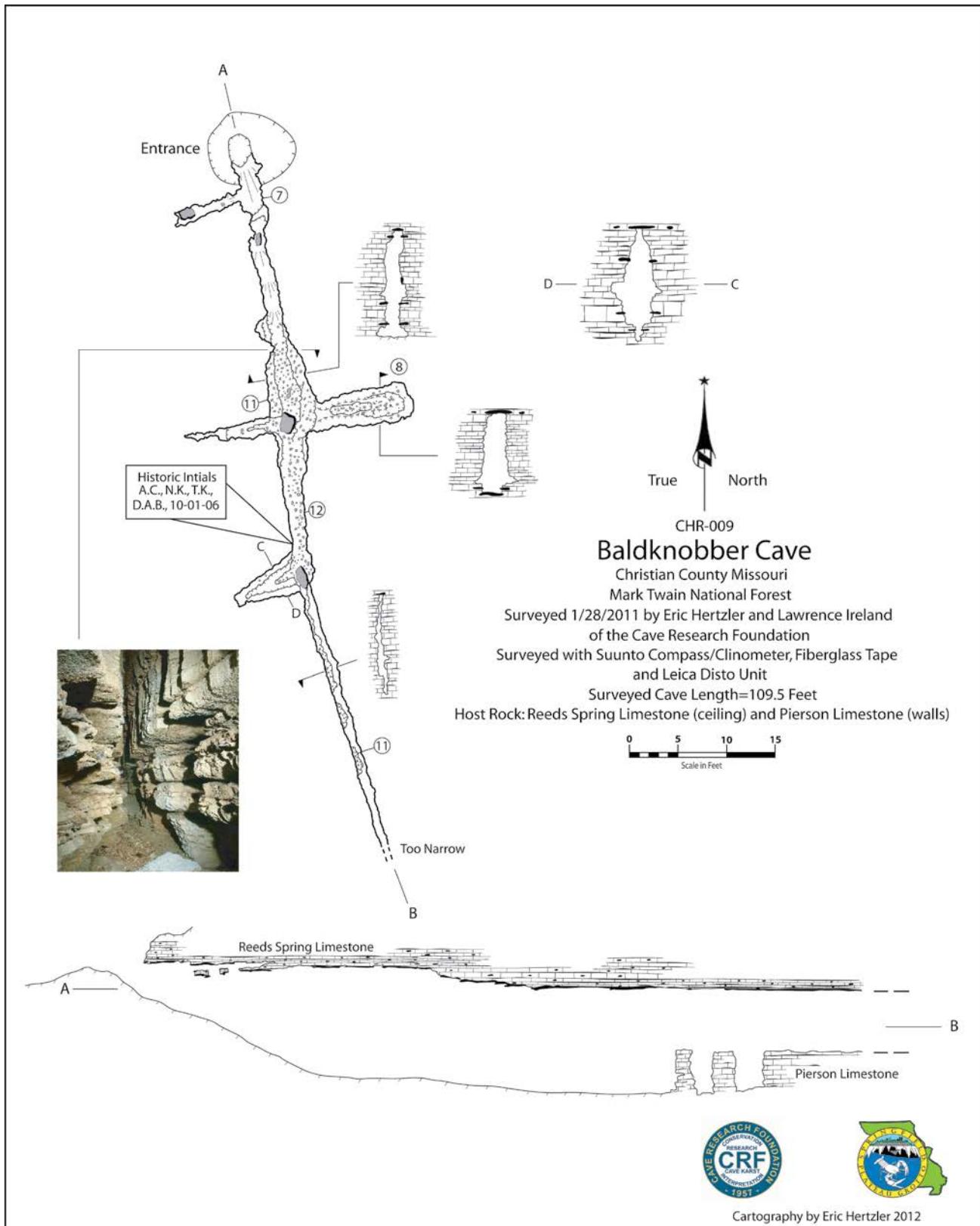
## Bass Pro Property

A new project was started on land owned by Bass Pro, Inc., a major sporting goods store. Bass Pro is doing a major development of a block of land, including development of a show cave (this perhaps understates the ambitious scale of the project). One field trip involved the largest and most expensive piece of vertical equipment this author has set

eyes on—a bucket lift with a greater than 100 foot reach. Ozark Operations is providing consultation to enable the show cave development to take place with conservation as a primary consideration, and a proposal is in the works to develop a management plan for all of the dozen or more caves on Bass Pro property. Another consultant on this project, who took part in the field trip, is long-time CRF Fellow LaJuana Wilcher.

## Berome Moore Cave

Another new project was inspired by the purchase of a major Perry County cave—Berome Moore Cave—by the Missouri Cave and Karst Conservancy and others. CRF, under Scott House's leadership, is collaborating with several other organizations in remapping this more than 20 mile long cave to modern standards.



## Missouri Department of Conservation

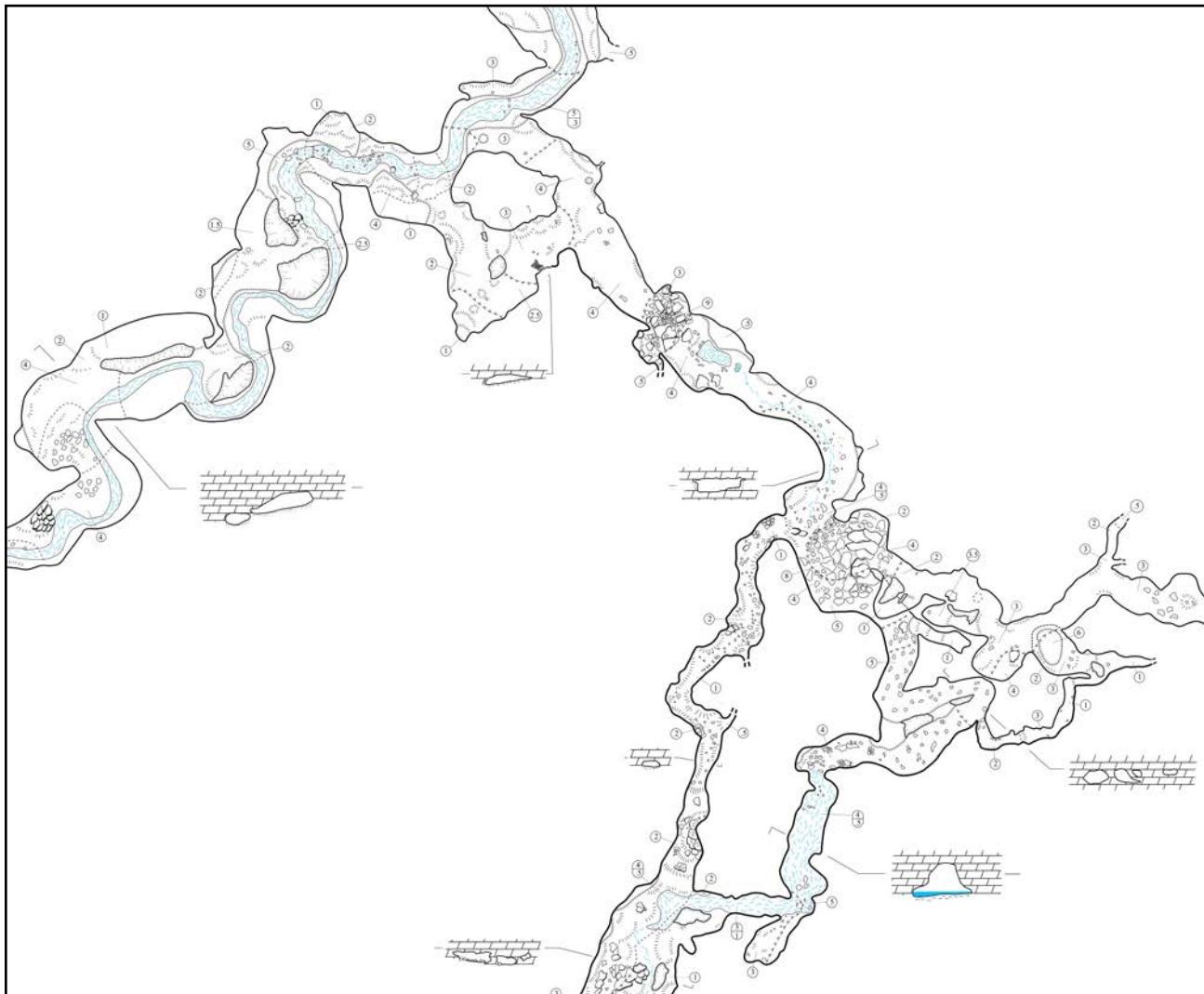
An unfunded Missouri Department of Conservation project continued with the completion of the first of four sheets of Powder Mill Creek Cave map and a good deal of progress on the more complex second sheet. Surveys continued on Shop Hollow Cave, a large stream cave on MDC land lying within the boundaries of the Ozark National Scenic Riverways; however that effort came to a halt (for now) when WNS was detected in the state.



*A group of grotto salamanders in Wind Cave, Ozark National Scenic Riverways and Pioneer Forest. Dan Lamping*

## Missouri State Parks

Continuing our tradition of working with the Missouri State Parks, several trips were taken to sort out caves in certain areas, map some un-surveyed caves, and perform biological



*A detail from the Crocker Cave map. Cartography by Dan Lamping.*

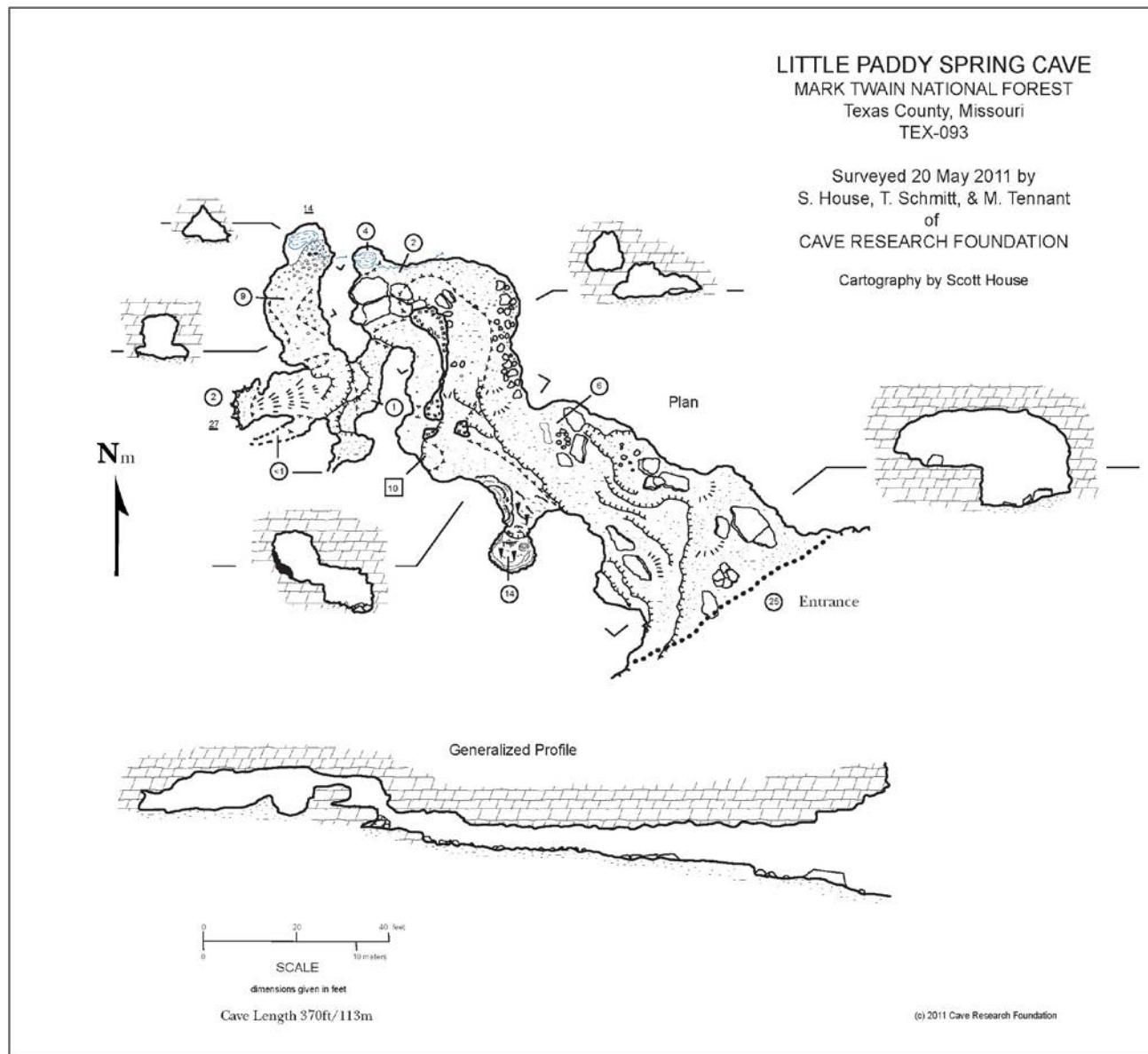
inventory. Trips were taken to Rockbridge Memorial State Park, Onondaga Cave State Park, and HaHaTonka State Park. Work has been supported by a research grant.

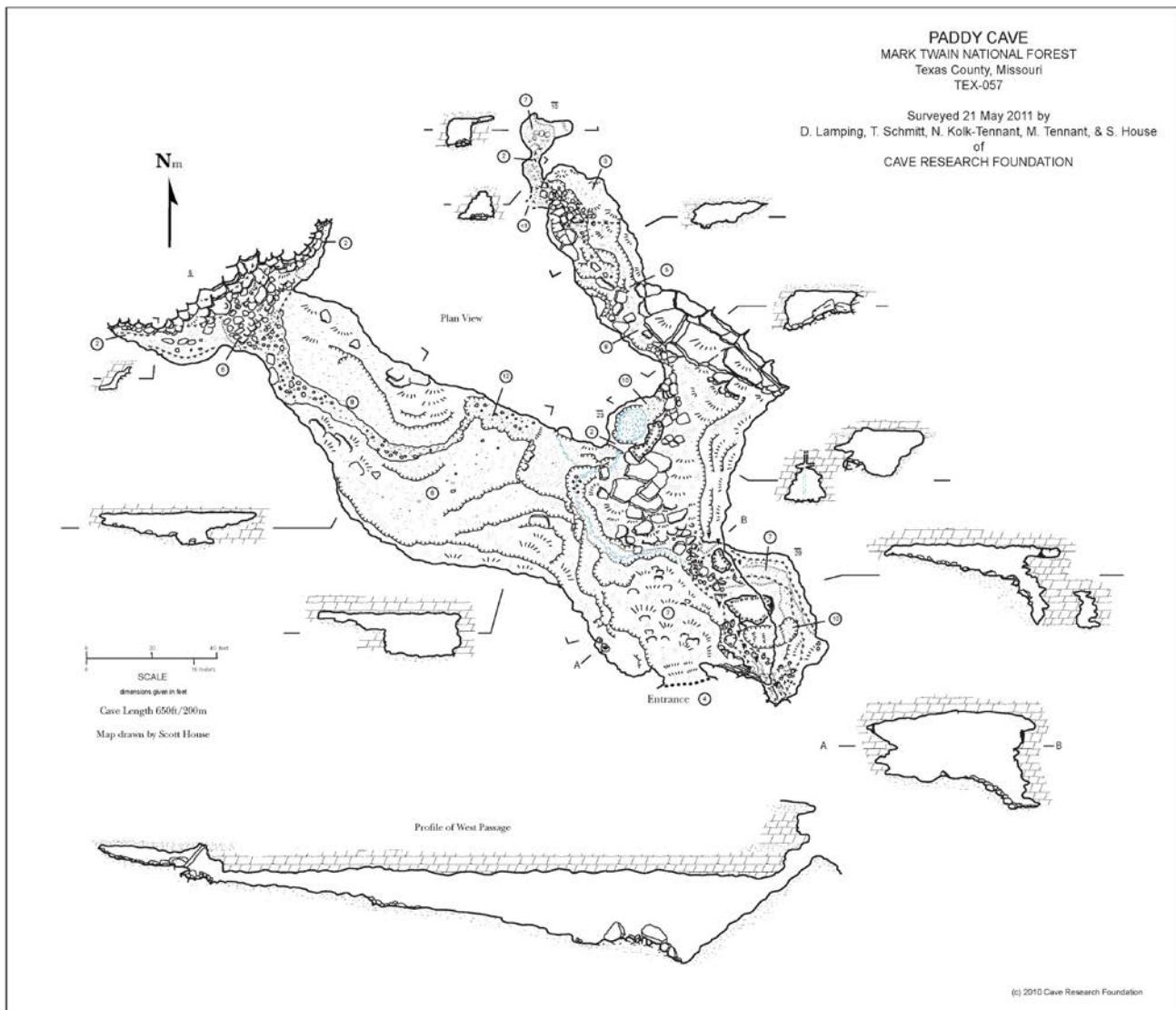
## Pioneer Forest

Missouri's largest private landowner owns more than 100 caves. CRF has supported occasional survey and inventory in them, while providing cave management consultation. Work is usually coordinated by Dan Lamping, who led two field trips onto Forestlands during this reporting period. Some of the caves mapped or monitored within the Ozark Riverways are on land actually owned by the Forest.

## Missouri Speleological Survey

CRF continues to collaborate closely with the Missouri Speleological Survey (MSS) and with individual NSS grottoes, especially with regard to additions and refinements to the cave files. Almost all Ozarks Operations work results in additions and corrections to the detailed cave records maintained by MSS, and Scott House continues to act as curator of those records on behalf of MSS.

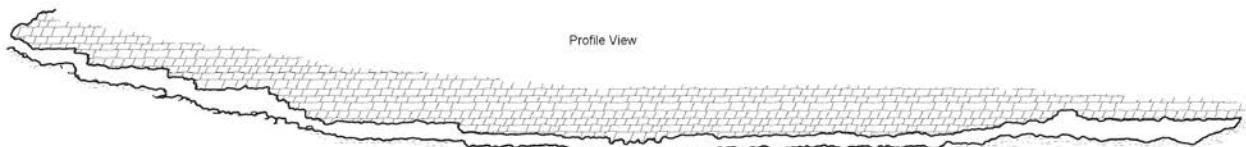
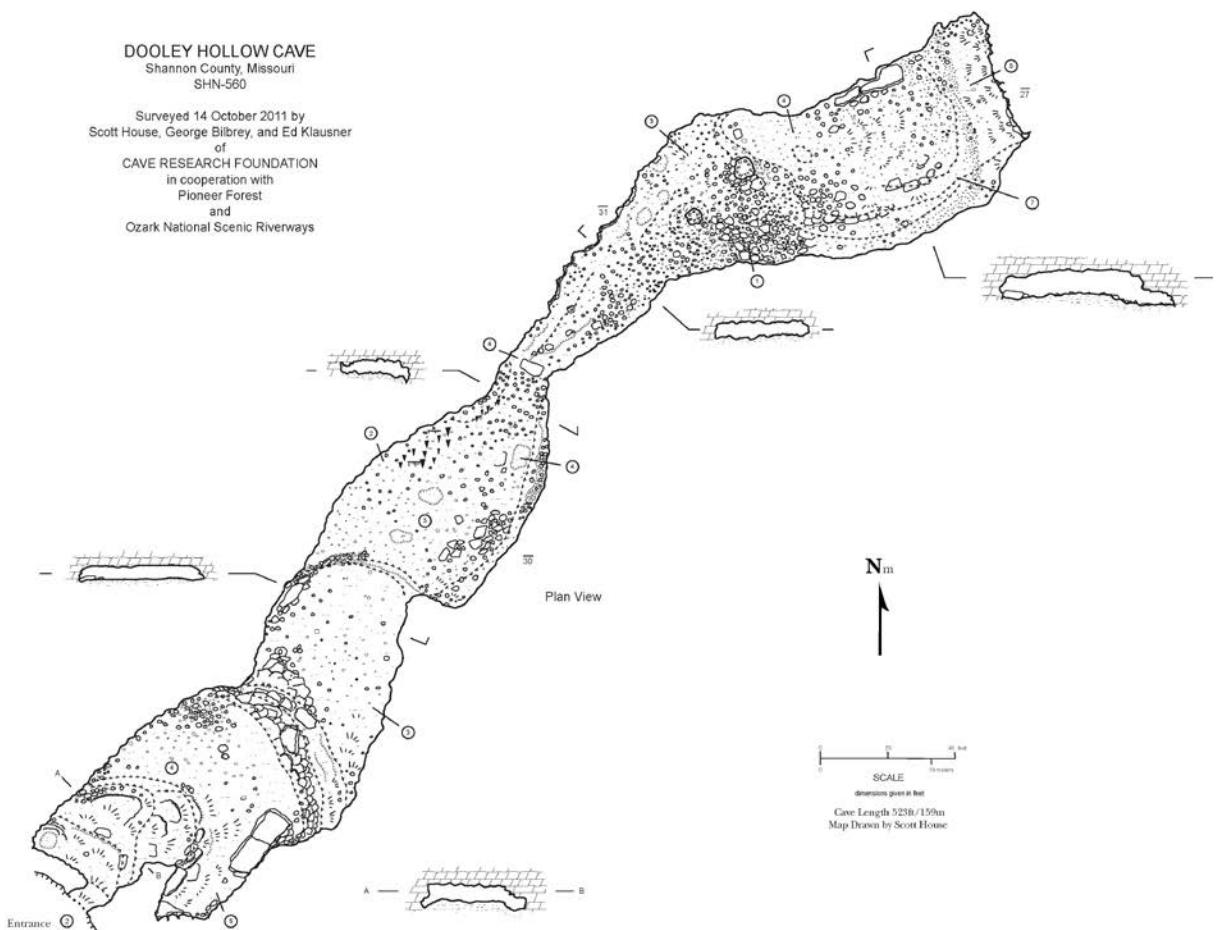




*Bob Lerch examines a strange oolitic nodule in Shamrock Cave, Ozark National Scenic Riverways and Pioneer Forest.*  
Dan Lamping

DOOLEY HOLLOW CAVE  
Shannon County, Missouri  
SHN-560

Surveyed 14 October 2011 by  
Scott House, George Blibrey, and Ed Klausner  
of  
CAVE RESEARCH FOUNDATION  
in cooperation with  
Pioneer Forest  
and  
Ozark National Scenic Riverways



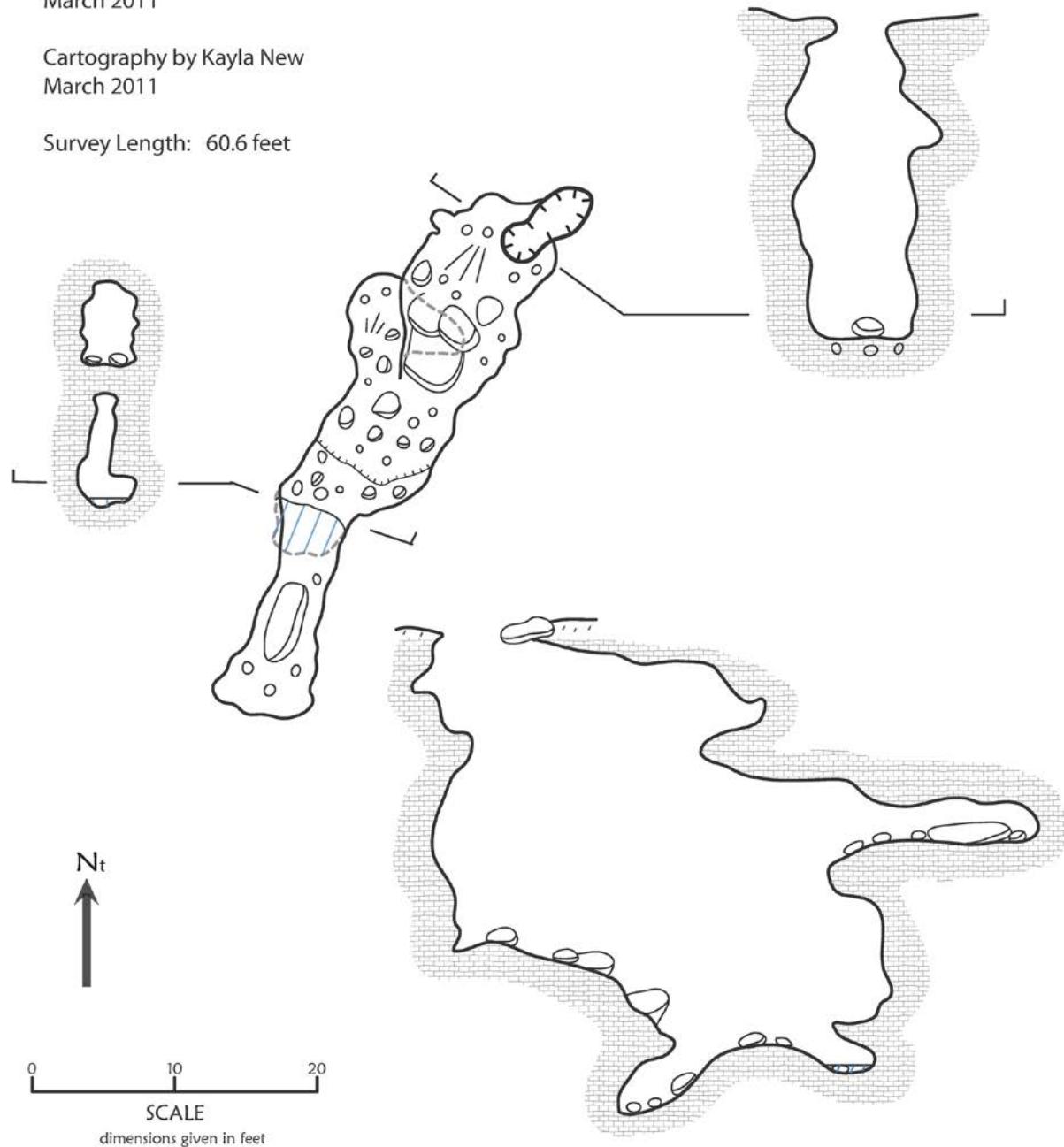
(c) 2011 Cave Research Foundation

Trillium Pit  
Buffalo National River  
C 320

Surveyed by Chad Holderfield & Kayla New  
of Cave Research Foundation  
March 2011

Cartography by Kayla New  
March 2011

Survey Length: 60.6 feet



(c) Cave Research Foundation

**Fowler Cave**  
Buffalo National River  
Newton County, Arkansas  
BUFF C234

Surveyed 07 Nov 2010 by  
Michael Tennant, Natalia Kolk Tennant and  
Bob Lerch of the Cave Research Foundation  
Fiberglass tape and Saunto Tandem survey  
All measurements expressed in feet  
Total Length Surveyed: 86 Feet (26 Meters)

Cartography by Michael Tennant

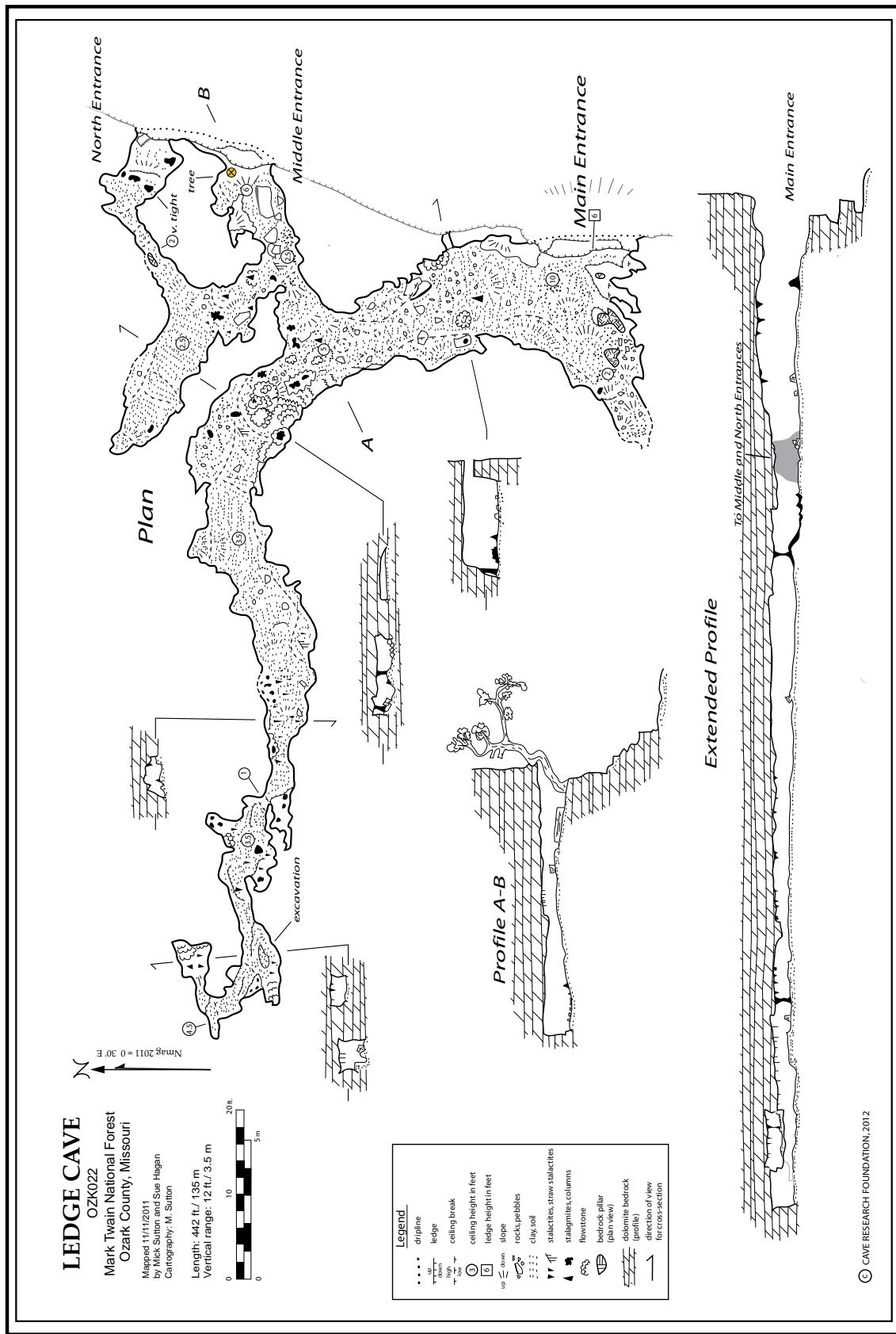


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	Floor ledge
+	Bedrock
↙	Floor Slope
△△	Rock/Cobble
—	Clay/Dirt
•••	Vegetative Debris
	Straws
○	Passage Height
□	Ledge Drop
▲	Datum Point

© CAVE RESEARCH FOUNDATION





## **Southwest Region**

**Barbe Barker**

*Area Manager, Southwest Region*

### **Summary for 11/2009 to 10/2010**

CRF Southwest has had a very productive year thus far working in a variety of areas and projects.

### **Carlsbad Caverns National Park**

Three expeditions were held at CCNP this last year: Presidents' Day, Memorial Day, and Labor Day expeditions. Thanksgiving was cancelled due to low sign up because of family responsibilities.

### **Survey of Carlsbad Caverns National Park**

Survey has continued in different areas of the cave. Kevin Glover, Survey Manager of CRF SW, has a project in the New Section. Tim Kohtz also has a project in the New Section, and David Engel is almost finished with The Mystery Room. Though projects are awarded to approved sketchers by the Cave Resource Office, CRF SW supports each of them with instrument personnel as well as a Scientific and Geology Inventory person on each team.



*Elizabeth Miller reading instruments in Carlsbad Cavern.*

*Ken Walsh*



**William Tucker marking a station in Carlsbad Cavern.**

*Ed Klausner*

### Restoration Projects in Carlsbad Caverns National Park

Ongoing restoration projects in Lake of the Clouds, The Guadalupe Room, Rookery III, and Crystal Springs Dome have continued during the year. Red Pool and Long Fellow's Bathtub have been counted as finished though we will continue to do maintenance on each.

As I stated last year, Crystal Springs Dome was at its lowest level in years and thus gave us a window to restore it. As of the writing of this report, the water has risen over 3 feet, and we are finished with the project except for maybe one trip and continued maintenance.

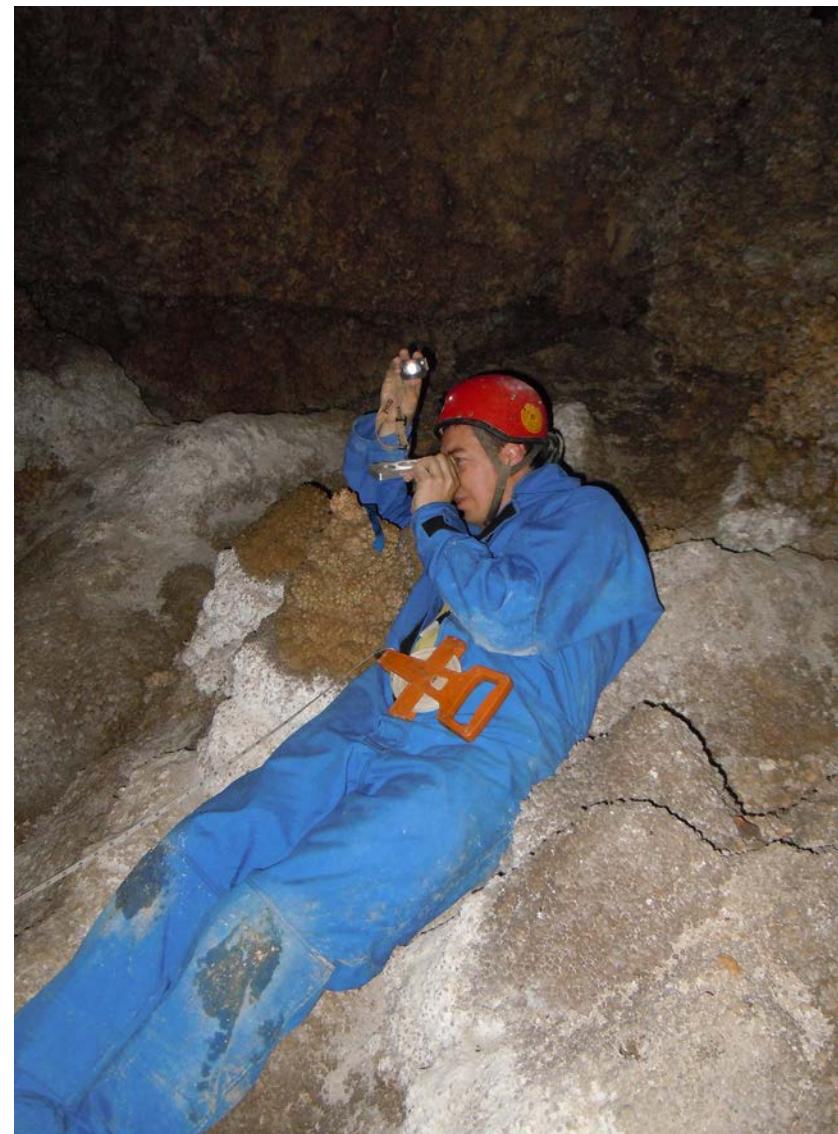
After two more night trips on Rock of Ages, we are within 1 to 2 trips of finishing the project.

### Summary

CRF SW continues to have a good working relationship with the Cave Resource Office of Carlsbad Caverns National Park.

### CRF Southwest Personnel List

- Area Manager: Barbe Barker
- Project Manager: Frank Everitt
- Assistant Managers: William and Tammy Tucker
- Personnel Manager: Bryant Bullard
- Writer: Deb Runyon



**Ken Walsh reading instruments in Carlsbad Cavern.**

*Ed Klausner*

Science



*A salamander in an Ozarks cave.*  
Joyce Hoffmaster

# The 2010 and 2011 Graduate Student Research Grant Programs

*George Crothers*

*Grant Program Chair*

In 2010 and 2011, the CRF grant program remained very active. Fourteen grant proposals were submitted in 2010, of which five were funded for a total of \$9,500, and nine proposals were submitted in 2011, of which four were funded for a total of \$9,890. The diversity of research topics and the number of students applying from a wide range of universities is an encouraging sign that cave and karst research remains an active field of inquiry. As always, a great debt of gratitude goes to the reliable group of grant reviewers who assist in the hard decision of funding the most deserving applicants, and to Treasurer Bob Hoke for awarding funds to the students in a timely manner. The annual deadline for grant proposals is March 1st, and the grant review team must complete their work by mid-April so that the funds can be disbursed in time for the student to hit the field at the end of the spring semester. Recipients for 2010 and 2011 are listed below along with their proposal abstracts. Short reports may also be found in this and future Annual Reports as the student research projects are completed.

## 2010 Grant Recipients

Matthew C. Batina (\$1,000)

*Department of Geography and Geology  
University of Southern Mississippi*

**Comparative, High-Resolution Pollen Analysis of a Stratigraphic Bat Guano Deposit and Proximate Lake Record to Evaluate Guano's Potential as a Paleoenvironmental Archive**

**Abstract**—To date, pollen studies of bat guano deposits have focused on the most modern guano samples only, and it is unknown if these deposits contain a stratigraphic pollen signal representative of the local environment that can be used to produce reliable paleoenvironmental reconstructions. Our understanding of guano pollen records

is hampered by the limited number of studies examining similarities and differences between pollen records from cave guano and the surrounding region. For this research I propose to conduct such a study using high-resolution pollen analysis to produce and compare detailed pollen records from a guano pile at Round Spring Cavern, Missouri and two lake sediment cores from the nearby Sunklands Conservation Area. These lake sites are within the foraging range of several species of bats that could have inhabited the cave (Sutton and House, 2006). As such, they will provide a better comparison than all previous pollen studies I have researched and help to determine how accurately the guano pollen records vegetation change over time. Moreover, because bats have likely influenced the pollen assemblage of their guano to some degree (Carrión et al., 2006), this study may yield information about past bat behavior and foraging strategies. Altogether, this research is expected to contribute baseline information on the relationships between fossil pollen, vegetation, and the bats and their guano to further pollen in guano deposits as a viable proxy for paleoecological study.

**Greg Brick (\$1,000)**

*Department of Geology  
University of Minnesota*

**Geochemical and Isotopic Study of Natural Nitrate Deposits from Upper Mississippi Valley Caves**

**Abstract**—Natural nitrate deposits are a poorly investigated part of the nitrogen cycle. It is proposed to examine the distribution and formation mechanism of natural nitrate deposits recently discovered in caves and crevices of the Upper Mississippi Valley, comparing them with known salt-peter caves of the southeastern United States and elsewhere. The methods used involve geochemical analysis and the stable isotopes of nitrogen and oxygen, bridging the fields of karst studies, geochemistry, and biology.

## Benjamin V. Miller (\$2,500)

*Department of Geography and Geology  
Western Kentucky University*

### ***Examining the Hydrology of Carroll Cave and Toronto Springs, Missouri through Groundwater Tracing and Geochemistry***

**Abstract**—In a karst area, the relationship between activities occurring on the surface and the overall health of the subsurface environment are highly interconnected. However, the complex nature of karst flow systems can often make identification of these connections difficult. Carroll Cave, a large stream cave system located in the central Missouri Ozarks, is known for its biological and speleological significance. A project to delineate a recharge area for Carroll Cave, through groundwater tracing, was initiated in Fall of 2008. As a result of this work, a preliminary recharge area of roughly 15 km<sup>2</sup> has been delineated. The water from Thunder River, within Carroll Cave, was positively traced to eight springs at a distributary spring system known as Toronto Springs. However, at least five other spring outlets at Toronto Springs appear to have independent sources not associated with Carroll Cave. Through examination of the geochemical properties of the individual springs, differences in water chemistry between the various outlets has become evident. Additional work with YSI Sonde dataloggers and water analysis seek to further define the variations in water chemistry, using carbonate chemistry parameters as additional “probes” to identify flow geometry. Sources thought to contribute water to the spring system include Carroll Cave, local surface streams, and other losing streams in the vicinity. By using dye tracing and creating geochemical fingerprints for the individual springs, the source waters and pathways for the springs at Toronto Springs are being identified.

## Donald A. Slater (\$2,500)

*Department of Anthropology  
Brandeis University*

### ***Investigations of the Central Yucatan Archaeological Cave Project: Caves, Power, and Legitimation in the Ancient Yaxcaba Region, Yucatan, Mexico***

**Abstract**—The Central Yucatan Archaeological Cave Project (CYAC) will conduct cave explorations in the Yaxcaba Municipal region of Yucatan, Mexico with the goal of developing a better understanding of caves’ role in socio-political and religious power struggles, and as stages of authoritarian legitimization, among the ancient Maya. Although gaining recognition as a critical component of

archaeological projects in the region, Maya cave research is still in its formative years. Many parts of the Maya world, including the permit area of CYAC, have undergone no previous cave exploration. CYAC seeks to fill this spatial and intellectual gap by contributing to archaeology in the Maya area, and more broadly to anthropological theory.

A dissertation feasibility study that I conducted in the Yaxcaba region during the summer of 2009 revealed abundant cave features which were utilized by the ancient Maya. As a result, I will assemble and lead two teams to carry out extensive research during the summer of 2010. With the aid of satellite imagery and local guides, the first team will search the jungle for previously undocumented caves and record related archaeological and spatial data for each feature. A second team will conduct preliminary excavations in select caves first located in 2010, which demonstrate strong potential to address CYAC’s research questions. Both teams will produce detailed 2D and 3D maps of caves using a variety of techniques. This work will serve as the springboard for a lengthier and more intensive field season in 2011.

## Benjamin W. Tobin (\$2,500)

*Aquatic Resources Program, Department of Biology  
Texas State University*

### ***Contributions of Karst Groundwater to Water Quality and Quantity of a Mountain River Basin under Varying Climatic Conditions: The Kaweah River, Sequoia and Kings Canyon National Parks, California***

**Abstract**—Under current climate conditions, hydrology of Sierra Nevadan rivers is primarily driven by three mechanisms: rainfall-runoff, snow accumulation and seasonal melting, and groundwater recharge, storage, and subsequent discharge. Snowmelt and groundwater both provide means of distributing seasonal precipitation events throughout the dry season. Snowmelt hydrology has been extensively studied, and its role documented in biogeochemical processes and maintaining river discharge. However, the extent to which groundwater contributes to these systems has yet to be quantified. As climate changes groundwater will potentially increase in its importance to maintaining essential ecological functions of these river systems. This project will quantify the current and historic contribution of karst groundwater within the Kaweah River in Sequoia and Kings Canyon National Parks and will model potential future responses of the karst aquifers to existing models predicting temperature and precipitation variation.

## 2011 Grant Recipients

### Monica Arienzo (\$3,000)

*Rosenstiel School of Marine and Atmospheric Science  
University of Miami*

#### *Bahamas Stalagmites as Recorders of Millennial Scale Temperature Variability*

**Abstract**—The impact of rapid climate change events, specifically Dansgaard/Oeschger cycles (D/O) and Heinrich events, in the subtropics is still not well understood. There are few high resolution studies from the subtropical Atlantic, and this project provides a unique opportunity to ascertain whether and how these events are recorded in the subtropics and how they compare to other records. In the proposed project, geochemical tools will be utilized to analyze the chemical composition of the speleothems to better understand the change in temperature associated with these rapid climate events in the Bahamas.

The main goal of this project is to determine temperature through clumped isotope analysis and fluid inclusion analysis. Fluid inclusion analysis relies on the extraction of water from microscopic cavities within the speleothem calcite. The extracted water represents the paleoprecipitation which is analyzed to determine temperature. In contrast, clumped isotope analysis relies on the measurement of the heavy, ex  $^{13}\text{C}$ - $^{18}\text{O}$  bonds in the stalagmite calcite. Clumped isotope paleothermometry is a relatively new area of research for cave studies and utilizing both methods will aid in the calibration and utilization of the clumped isotope paleothermometer. These results will be compared to the timing and duration of these events in deep sea sediment records and ice core data from Greenland to understand the relationship between the subtropics and high latitudes. This project will aid in the crucial development of more accurate regional models for the subtropics during rapid climate change events.

### Erika Crespo (\$3,150)

*Department of Earth and Environmental Sciences  
University of Texas at Arlington*

#### *The Mayan Culture-Climate Interactions Revealed through a Composite Speleothem Record*

**Abstract**—The ancient climate for the pre-Columbian Maya of Mexico, Belize, and Guatemala is poorly understood. Although anthropological studies on the collapse of this civilization have revealed it to have been primarily climate-induced, there is significant variation in the timing and duration of the events. Previous researchers have attempted to use lake bottom sediments to reconstruct regional climate conditions, but cave deposits, in particular stalagmites, provide a more precise and detailed environmental record (Fleitmann et al., 2008). The stable isotope signatures ( $\delta^{13}\text{C}$  and  $\delta^{18}\text{O}$ ) and the trace metal geochemistry (e.g., Sr/Ca, Mg/Ca, Ba/Ca) of the calcite formations archive temperature, humidity, and precipitation conditions. Additionally, the analysis of cave drip waters serves as a calibration technique with current cave conditions. The use of this type of climate reconstruction can aid in our understanding of recent and future climate trends. This proposed study seeks to understand the linkages between cave formations, regional hydrology, and the climate system of the Yucatan Peninsula in southern Mexico.

It will include a detailed analysis of multiple stalagmites, drip water samples, precipitation collections, and modern-forming calcite deposits using a variety of geochemical methods. An initial study was conducted at San Eduardo Cave near Tecoh, Yucatan Mexico. Additional caves in the region, as yet to be determined, will be investigated for study suitability. Such a task will ensure that this study provides a more regional context for climate changes. It will also offer a thorough view of the cave-climate system dynamics, which is presently lacking in the scientific literature.

## Kendra L. Phelps (\$1,500)

*Department of Biological Sciences  
Texas Tech University*

### ***Prioritizing Karst Formations to Conserve Cave-Dependent Bats in the Philippines***

**Abstract**—In the Philippines, karst formations represent critical areas for biodiversity. Numerous bat species are dependent upon solution caves weathered into karsts to provide a stable environment suitable for roosting and rearing young as well as shelter from predators and adverse weather. Solution caves house some of the largest and most diverse aggregations of bat species in the world. Cave-dependent bats are considered keystone species because of the vital ecological and economic services they provide, specifically pollination, seed dispersal, and pest control in addition to providing the only nutrient input (guano) in caves. Unfortunately, cave-dependent bats are being threatened by human disturbances at multiple scales in karst landscapes, including widespread disturbances like quarrying and logging, which result in the direct loss of roosting and foraging sites. Localized disturbances, such as unregulated hunting, cave tourism, and guano extraction, add additional pressures. Such human threats jeopardize the viability of cave bat populations in the Philippines. Thus, to determine the response of keystone bat species to increasingly human-dominated karst landscapes, my study aims to compare cave-dependent bat assemblages among karst formations experiencing differing levels of human disturbance on Bohol Island, an island centrally located in the Philippines. Specifically, I will document ecological characteristics (species diversity, composition) and general health parameters (body condition, ectoparasite loads) of cave-dependent bats across karst landscapes on Bohol Island that experience minimal, moderate, and high levels of disturbance. Results from my study will be used to identify priority karsts for protection to improve cave bat conservation in the Philippines.

## Wendy Whitby (\$2,240)

*School of Forensic and Investigative Sciences  
University of Central Lancashire, UK*

### ***AMS Dating of Archaeological Basketry Samples from Cache Caves in South-Central California***

**Abstract**—Distributed across the mountainous region situated just inland from Santa Barbara, in south central California, a number of dry caves have yielded more than 700 Native American artifacts. Xeric conditions in the caves have resulted in exceptional preservation of organic materials, and the cached objects include feather headdresses, wooden bullroarers, bone whistles, matting, bundles of plant materials, and large quantities of basketry. Indigenous material culture in California would have comprised a very high proportion of organic material but it is rare for archaeologists to have the opportunity to study objects such as these. The artifacts collected from these caves are now mostly housed in museums in the USA and their study enables consideration of indigenous subsistence, ritual, and ceremonial practices. Most of the region under study was occupied from prehistoric times by the Chumash people but the mountainous interior is relatively under-studied compared to the coastal Chumash zone. Study of cache caves and their artifacts thus provides an opportunity to redress this balance.

My doctoral research is primarily combining archival research with museum-based study of cache cave artifacts. This should enable classification of artifacts and geographic based distribution studies. A further key objective is to construct a chronological framework for the use of cache caves, and I propose to carry out a small program of AMS dating on basketry specimens that are accessioned at Santa Barbara Museum of Natural History.

# Bahamas Stalagmites as Recorders of Millennial Scale Climate Variability

Monica Arienzo

Rosenstiel School of Marine and Atmospheric Science, University of Miami

## Introduction

The last 100,000 years of global climate are punctuated by rapid climate change events such as Dansgaard/Oeschger (D/O) cycles and Heinrich events. Heinrich events are characterized as global, rapid climate events and were first identified in the geologic record from the deposition of ice rafted debris (IRDs) in the North Atlantic (Bond et al., 1993; Bond et al., 1992; Bond et al., 1997; McManus et al., 1999). These cold (stadial) events are associated with the southerly extension of the North Atlantic ice, an increase in freshwater discharged into the North Atlantic and a reduced Atlantic Meridional Overturning Circulation (AMOC) (Broecker et al., 1985; McManus et al., 2004). From models and proxy data, there is evidence of an inter-hemispheric climate response, including a decrease in sea surface temperatures (SSTs) in the northern hemisphere and increased SSTs to the south (Chiang, 2009; Clement and Peterson, 2008; Voelker, 2002).

Various types of paleoclimate data support the global nature and scale of Heinrich stadials and D/O interstadials. While a comprehensive picture of climate across Heinrich events is emerging for the North Atlantic, very few studies have been conducted in the subtropical western Atlantic, which may be an important area for investigating the global propagation of these events. In this study, we have attempted to further understand sub-tropical climate using geochemical records from multiple speleothems from a flooded cave in the Bahamas. These Bahamian stalagmites demonstrate increased aridity and temperature decrease associated with Heinrich events.

## Methods

Speleothems collected at depths ranging from 10–40 meters below modern sea level were dated using U-Th geochronometry with MC-ICP-MS at the Neptune Isotope Laboratory of

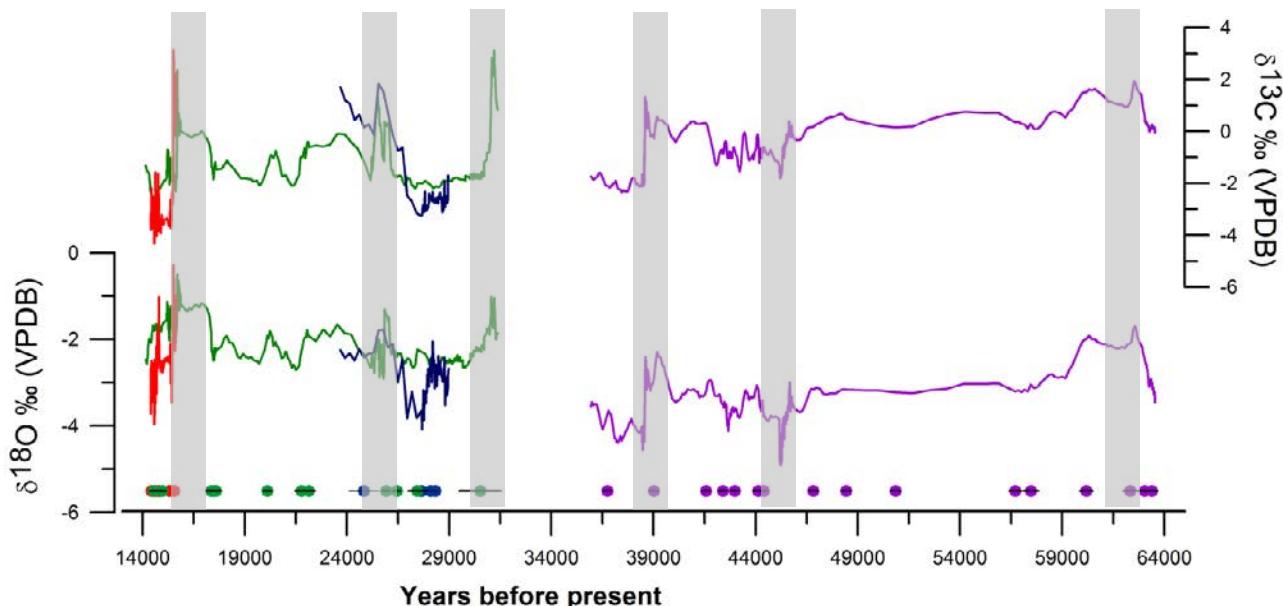


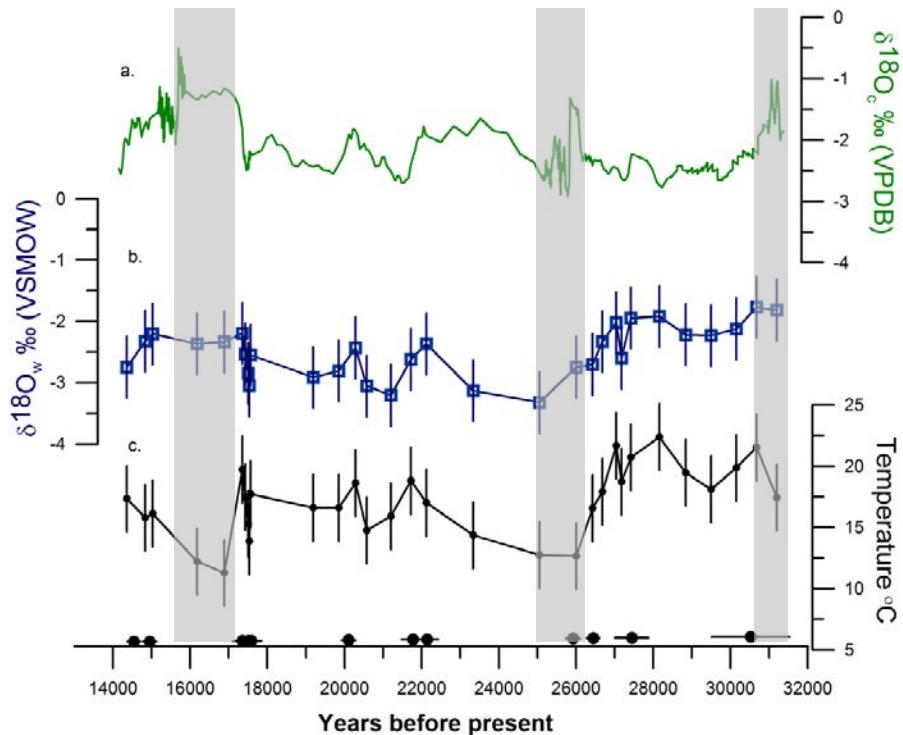
Figure 1: Geochemical results for four different stalagmites. Each stalagmite is represented by a different color. Carbon and oxygen isotopes of the carbonate demonstrate increasing values leading into Heinrich events 1–6. Note the good agreement between samples from the same cave. Grey bars represent the timing of Heinrich stadials 1–6.

the University of Miami—RSMAS using the methods from Pourmand et al. (2014). Stable carbon and oxygen isotopes were measured at a resolution of 1 mm. Interpreting the  $\delta^{18}\text{O}$  of carbonate is inherently difficult because the  $\delta^{18}\text{O}$  of a carbonate is dependent on both the variations in temperature and the  $\delta^{18}\text{O}$  of the cave water. In order to solve for the second unknown, an additional proxy, such as water extracted from fluid inclusions, is needed to provide information on one of the two unknowns. Fluid inclusion isotopic analysis provides information on the isotopic ratio of the formation water that can be used to calculate paleo-temperature. One stalagmite was analyzed at a resolution of 1 sample every 0.75 cm for fluid inclusion isotopic analyses.

## Results

U-Th age results from multiple speleothems from Dan's Cave, from Abaco Island, Bahamas

demonstrate the stalagmite samples were forming from  $\sim$ 13 to 65 ka. The carbonate  $\delta^{18}\text{O}$  and  $\delta^{13}\text{C}$  results reveal significant isotopic excursions associated with Heinrich events 1–6 from each of the stalagmites (Figure 1). This increase is followed by more negative values at the terminations of the events (Figure 1). The increase in  $\delta^{13}\text{C}$  is possibly thought to be either a decrease in temperature or increased aridity which leads to a reduced biogenic  $\text{CO}_2$  component resulting in an increase in the carbon isotope value across Heinrich stadials (Figure 1). Interpreting the  $\delta^{18}\text{O}$  of the carbonate is inherently difficult due to both temperature and the  $\delta^{18}\text{O}$  of the water influencing the  $\delta^{18}\text{O}$  of the carbonate. In contrast to increased  $\delta^{18}\text{O}$  of the carbonate associated with all Heinrich events, the  $\delta^{18}\text{O}$  of the water obtained from the fluid inclusions supports minimal change in  $\delta^{18}\text{O}$  of the water during these events (Figure 2). The fluid inclusion data suggest that temperature, rather than precipitation amount, is the primary driver of the shift in the oxygen isotopes of the carbonate (Figure 2). Utilizing the Tremaine et al. (2011) equation, which defines the temperature dependent fractionation relationship for speleothems, temperature for the sample was calculated. Heinrich stadials 1, 2, and 3 are characterized by cooler temperatures (Figure 2), with Heinrich



**Figure 2: Geochemical results from one stalagmite.** A) oxygen isotopes of the carbonate (same as green above) demonstrate increasing values across Heinrich events. B) Fluid inclusion oxygen isotope results demonstrating minimal isotopic change across Heinrich events. C) Temperature calculated from the fluid inclusion results and the carbonate results supporting decreasing temperature across Heinrich stadials.

stadial 1 being the coolest event. The average temperature across Heinrich events 1, 2 and 3 was 15.3 °C (Figure 2).

## Conclusions

Based on our results, there is good geochemical agreement between stalagmites from the same cave across the studied time interval. This validates that the geochemical proxies in the stalagmites record climatic changes and are not influenced by kinetic effects. These Bahamian speleothem records, and other proxies from the subtropical/tropical western Atlantic, indicate drying/cooling associated with Heinrich stadials. This climate response is thought to be driven by a southerly shift in climate due to decreased SSTs in the North Atlantic (Escobar et al., 2012; Peterson et al., 2000; Schmidt et al., 2004; Soto, 2005). These records support the link between high latitude North Atlantic climate and the temperature of the subtropics.

These results were presented at the American Geophysical Union Annual Meeting in San Francisco, CA in the winter of 2013 and will be submitted for publication in the near future.

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# Le Sueur's Saltpeter Caves at Lake Pepin, Minnesota

*Greg Brick*

*Department of Earth Sciences, University of Minnesota*

Prompted by French fur-trader Pierre-Charles Le Sueur's 1700 report of caves containing saltpeter (potassium nitrate) along the Minnesota shore of Lake Pepin (Conrad, 1971), this study investigated nitrate concentrations in cave sediments along the Mississippi River bluffs in Minnesota and to a lesser degree the entire Upper Mississippi Valley (UMV), including Wisconsin, Illinois, and Iowa. Thus, caves on both sides of Lake Pepin, and further up and downriver, were investigated, not merely those in the immediate area suggested by Le Sueur's Journal. The caves were hosted in a variety of lithologies: dolomites, limestones, sandstones, and basalts, ranging in age from Precambrian to Pennsylvanian. For comparative purposes, sediments were also collected in Minnesota's two largest caves, Mystery Cave, near Spring Valley, MN, and Niagara Cave, near Harmony, MN. Great Saltpetre Cave, Rockcastle County, Kentucky, which has a known history of saltpeter extraction, was also sampled. Surface soil control samples were systematically collected along slope profiles and along the tops of the bluffs in places where considerable concentrations of caves were identified.

Cave sediment sampling protocols were adapted from the research of Fliermans and Schmidt (1977) at Mammoth Cave, Kentucky. They found that surface soils above Mammoth Cave were "always less" than 25 parts per million (ppm) nitrate-nitrogen ( $\text{NO}_3\text{-N}$ ), which is equivalent to 110 ppm nitrate ( $\text{NO}_3$ ), so this value was adopted as a lower limit for samples demonstrating nitrate enrichment. A preliminary indication of the nitrate content of the sediments and soils was made by dipping commercially available nitrate test strips, which yield semi-quantitative values based on changing indicator colors, into slurries prepared from the samples by adding distilled and deionized water. Solutions showing elevated nitrate concentrations were passed through a 0.2-micron filter and sent to the analytical laboratory at the Department of Earth Sciences, University of Minnesota, for chemical analysis.

Of the nearly one hundred caves (including small, unenterable rock voids) sampled in the UMV, about half had elevated concentrations of nitrate, as determined by the nitrate test strips. Laboratory analysis confirmed the indicator strips and provided quantitative values that could be related to dry weight of sediment. High nitrate concentrations, up to 35,000 ppm (3.5 percent) dry weight of sediment, were widespread among rock voids along

both shores of Lake Pepin and occurred as far south as sampling was conducted in Illinois. By contrast, none of the surface control soils showed more than 10 ppm nitrate. In retrospect, using a lower value based on the control soils, approximately two-thirds of the caves would have shown nitrate enrichment.

UMV sediment nitrate concentrations are comparable to those found at Mammoth and Dixon caves, Kentucky, an historical nineteenth-century saltpeter mining locality, which range up to 4% (Hill, 1981). This is enough to show that Le Sueur's claim of finding saltpeter (more likely, a saltpeter precursor, such as calcium nitrate) in Minnesota caves, for making gunpowder in the wilderness, is credible, but other considerations, such as the small quantity of sediments available and the difficulty of accessing them, raise serious doubts. In any case, this remains the earliest report of cave saltpeter from America, predating more probable French saltpeter manufacture from Missouri caves in 1720, described by Breckenridge (1925).

The source of the nitrate found in the cave sediments is a focus of the research. The most widely accepted theory for the accumulation of nitrate in the large, historic saltpeter caves of the southeastern United States, such as Mammoth Cave, involves the groundwater seepage model proposed by Hill (1981). Organic nitrogen is converted to ammonia in surface soils and drawn into the cave through the limestone walls by a moisture-density gradient created by evaporation at the cave air-bedrock interface. Ammonia is converted into nitrate by nitrifying bacteria known to exist in the cave sediments. This model can account for the elevated nitrate concentrations obtained during this study from samples taken in Great Saltpetre Cave, Kentucky. But Minnesota is located far outside Hill's optimal area, and the conditions necessary for her model to work do not seem to apply here. Thus, sediments taken from the driest parts of the largest Minnesota caves during this study, Mystery and Niagara caves, revealed the total absence of nitrate (0 ppm).

Some other possible sources of the nitrate-nitrogen in the UMV crevices were excluded. The high nitrogen does not derive from host rock disintegration or dissolution, as concentrations of nitrogen in the predominant dolomite are relatively low and there are few speleothems. Although some of the river bluffs are farmed on their summits, presumably involving the application of nitrogen fertilizer, the cave's nitrate-nitrogen does not match isotopically with the

nitrogen of artificial fertilizer, nor does it match the nitrogen fixed by lightning, found in rainfall; instead, it bears the signature of nitrogen that has been affected by microbial processes (Brick, Alexander, and Doctor, 2009). Moreover, some high nitrate samples were obtained from voids in barren rock pinnacles that could never have been farmed.

At present, it is conjectured that animal traffic and plant debris add organic matter to the cave sediments, which undergo microbial nitrification, forming nitrate, which then accumulates because the cave roof protects the sediment from leaching and by shutting out sunlight permits this plant nutrient to remain in the sediment.

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# Emerging from the Underworld

Highlights and Preliminary Interpretations of the 2011 Season of the Central Yucatan Archaeological Cave Project (CYAC)

**Donald A. Slater**

*Ph.D. Candidate, Department of Anthropology, Brandeis University  
Educator, Robert S. Peabody Museum of Archaeology, Phillips Academy*

During the 2008 to 2010 CYAC field seasons my team and I documented approximately 100 previously unrecorded caves in the Yaxcaba Municipality of Central Yucatan, Mexico. This reconnaissance revealed abundant activity which once occurred in these caves from at least the Middle Formative period (as early as 800 BC) until after the Spanish Conquest. Evidence includes a high density of ceramics found on cave floors, as well as modifications to caves' interior space in the form of petroglyphs, stairways, and walls. This rich evidence held great promise for further investigation and as a result CYAC embarked on a four month field season from April through August of 2011 to excavate and further document four of the region's most significant and heavily utilized caves.

In summary, these investigations intend to address two main research goals: (1) to analyze the ways caves located within major elite urban contexts were used in comparison to those found in more suburban or hinterland settings, and (2) to determine how various zones within caves were differentially utilized both spatially and temporally. Methodologically, these questions were approached by selecting four caves for intensive investigation—two within significant elite complexes at the sites of Ceh' Yax and Ikil, and two others, Aktun Kuruxtun and Aktun Jip, located outside of any direct spatial linkage with major site complexes. Spatially, excavations were placed in each of the different physical zones within caves including light zones such as cave mouths, twilight zones deeper within caves but still in view of the cave mouth, and last, dark zones. In total, approximately 50 excavation units ranging from 50 × 50cm to 2 × 2m (with 1 × 1m units being the most common) were dug to depths ranging from only a few centimeters to almost four meters. Additionally, surface collections covering the entire floor area of Aktun Jip, Aktun Kuruxtun, and Cenote Ceh' Yax were conducted to help determine overall spatial usage of these caves. Finally, all non-portable cultural modifications within caves were recorded with the goal of constructing an attribute analysis table of each cave for comparative purposes.

Given the enormous amount of data collected in the field this season, most analysis and interpretative work

are still pending. However, in this report I hope to present some of the season's highlights and raw data as well as several preliminary interpretations that I have constructed thus far. Last, I will briefly touch upon plans for continued lab analysis and further research in the area. When final results of the project are distributed in the form of my dissertation, hopefully some time in 2013, a copy will be sent to the Cave Research Foundation.

Thus far, attribute analysis and comparison of the cultural modifications and traits present in each of the four study caves implies a high level of standardization and replication of activities between caves within and outside of elite urban areas. Major traits which span both cave types include the presence of *metates*, staircases, masonry walls, speleothem removal, displaced architectural elements from surface sites, and two other features which will be highlighted in this report—pathways and petroglyphs. Fewer traits were found in only one cave type. Overt mining activity is present only at the hinterland caves of Aktun Jip and Aktun Kuruxtun, whereas the cave within the main complex at the site of Ikil contains an astronomical observatory—an extremely rare trait for any cave.

The presence of pathways suggests that standardized routes of procession and ritual activity were laid out within major caves in the area regardless of their central or peripheral locale. The best example is located within Aktun Jip and was the focus of our excavations in that cave. Upon first exploring the cave in 2009, a marked difference was noted between a clear corridor of packed soil leading toward a pool at the back of the cave, versus a debris and rubble filled area running alongside it against the east wall of the cave. Such juxtaposition hinted at the existence of a carefully maintained pathway. Investigations this season have confirmed this proposal by uncovering thick layers of artifacts dating from 800 BC to post-contact along the cave wall. This artifact assemblage included ceramics, obsidian blades, decorative ornaments, and human bone, while excavations on the proposed pathway exposed few artifacts but revealed an outstanding stratigraphic sequence of two phases of packed limestone floors which terminate at the edge of the debris zone.

Extensive petroglyph programs were recorded in Aktun Kuruxtun in 2009, as was a petroglyphic monument in Cenote Ceh' Yax in 2010. More detailed reconnaissance in both areas this season revealed additional signs inscribed on the walls and ceilings of these caves. Most notable is a program on the ceiling of the Petroglyph Chamber of Aktun Kuruxtun which features a bird facing a seated individual with a spiked helmet or rays emanating from his head. Additionally, in this chamber, another new petroglyph was discovered in a peculiar area—a thin notch between the south and west petroglyph panels. Despite the fact that it is impossible to contort one's body to fully view the petroglyph due to its extremely confined location, the program is certainly the most finely executed example discovered thus far in the research area. Unfortunately, its situation does not allow adequate photography or scanning and the stone's surface is too fragile to produce a rubbing. At this point, it is only possible to detect a complex scene of undulating lines. Regardless of the content, the fact that it is hidden from human view may be key to partially understanding the original intentions of the artist. People were likely not the intended audience, but instead it was inscribed for any of a variety of deities or ancestor spirits that were believed to dwell in the cave.

Despite the great similarity of cultural modifications such as petroglyphs and pathways found at the four study caves, one particular trait stands out as unique at Ikil Cave 1—a solar observatory. The cave is situated within the core of the little known site of Ikil. The rim of the *rejollada* where the cave is located abuts the edge of the platform of the site's Structure 1, a 26-meter high radial pyramid that is similar in size and form to El Castillo at Chichen Itza. As revealed during this season's excavations, in ancient times the steep entrance into the small mouth of the cave was navigated via a staircase. Entering straight into the cave another set of stairs is encountered leading lower into the chamber. To the left at the bottom of this small course of steps is a single observation area within the cave that affords a unique view of the outside world. Here the center of the scene is dominated by Structure 1. Research this season has demonstrated that this alignment was not coincidental. Instead, Structure 1 was built to mark the sunrise on the day of the May solar zenith passage each year—a vital date that denotes the all important beginning of the rainy season. I believe that the construction of such alignments was a way of formalizing and ritualizing important astronomical events, while perhaps also spatially and ideologically linking together different layers of the cosmos and ritual landscape.

As viewed from the observation point within the cave, the sun will rise directly above the apex of Structure 1 on this day. Though it is extremely rare for such a solar observation point to be located within a cave, the fact

that Structure 1 figures in an astronomical alignment is unsurprising. Scholars have long noted the connection between solar alignments and radial pyramids at sites such as Chichen Itza, Dzibilchaltun, and Uaxactun.

This connection between Structure 1 and Cave 1, and the layout of Structure 1 itself, may help explain confounding results gleaned from the mapping project at the site. After CYAC's parent project led by Travis Stanton and Aline Magnoni completing a map of the site core from 2008 through 2011 it has become clear that the only building at the site that stands out as truly monumental is Structure 1. Given the similarities it shares in size and form with El Castillo at Chichen Itza, and the level of political power and control that must have been wielded to construct such a monument, it is peculiar that not even one other structure at the site is of the magnitude that would be expected to complement Structure 1. One potential explanation is that the site was not an economic and political population center like Chichen Itza, but instead was a satellite set up as a pilgrimage site with the pyramid and cave complex as the central focus. In addition to the zenith hierophany that would have been an important annual event at the site, the pyramid also served another vital ritual function. Two hieroglyphic lintels at the summit of the pyramid identify two niches which are described as "sleeping places" a term which refers to special abodes constructed for idols of deities which were believed to be animate.

Few, if any, elaborate housing structures matching what scholars identify as elite residences have been found at the site—with the exception of rooms located on the three platforms of Structure 1. I suggest that these quarters were used to house dignitaries visiting the site or perhaps a small population of ritual specialists charged with keeping watch over the "sleeping places," whereas the remainder of the site with its modest architectural program was home to a small full-time resident population.

Given the similarities of the size and form of the dominant pyramids at both Chichen Itza and Ikil, their association with major solar hierophanies, their shared linkage with a major cave feature at each site, and preliminary ceramic analysis identifying a strong presence of Chichen style ceramics at Ikil, it is not unreasonable to suggest that Ikil was in fact a pilgrimage site controlled by, and perhaps founded by, Chichen Itza.

In addition to the features and traits previously discussed within the four caves in my study, portable objects recovered during excavation and surface collection also revealed great similarities, though still some differences, between the two categories of caves. By far, the most common artifacts recovered were ceramic fragments—totaling approximately 37,000 sherds. All four caves contained dense ceramic deposits. Faunal material was also extremely common throughout, however due to the fact

that many animals live, die, and eat in caves few specimens can securely be assigned a cultural context. Lithics were fairly uncommon in all caves, but were found. Obsidian blades were present in each cave. Of interest, however, is the diversity within the types of materials recovered from the above categories. Based on other scholars' cave investigations, an abundance of polychrome ceramics was not expected. In our investigations two of the four caves produced several dozen polychrome sherds. Contrary to expectations, assemblages from neither cave located directly within elite urban complexes included these materials. Instead, both caves outside of these zones contained polychrome sherds. Moreover, not only are polychrome materials considered to be elite luxury goods, but the vast majority of these sherds were not of local manufacture, but instead were more finely crafted expensive imports. Additionally, prized green obsidian imported from Pachuca, Mexico was also found at two locals within Aktun Kuruxtun. Why were overtly elite artifacts found with much greater frequency, almost exclusively, in the caves outside of elite complexes? Is this a function of the time periods that are represented in the archaeological record within the cave? Or since elites were operating outside of their immediate royal setting, were they using prestigious imported goods to reinforce their status to onlookers and participants in cave rituals at Aktun Jip and Kuruxtun? Or is there another explanation? Ceramic studies, radiocarbon dating, and further interpretive analysis planned for 2012 will hopefully tease out the details.

Though a comprehensive analysis of the distribution of materials recovered throughout the four caves has yet to be completed, one key observation was made in the field—artifact density dramatically decreases, in most cases virtually disappears, once the threshold into a cave's dark zone is crossed. This observation holds true for each of the four caves in the study area that contain dark zones—Aktun Kuruxtun, Aktun Jip, and Ikil Cave 1. I do not believe this to be the result of a utilitarian difference in available light for vision. Many areas of the twilight zone are functionally dark, although trace elements of light from the cave mouth can still be seen in the distance. Activity levels remain high in these areas despite the need for the use of torches for functional light. Instead, it seems that the difference in activity level from the light/twilight zones to the dark zone is based on ideological concepts of space which differ from zone to zone within caves. As such, the dramatic drop off in artifact density in dark zones suggests that these spaces were seldom accessed and may have been

ideologically off-limits to all but the most specialized ritual practitioner—a conclusion for which there is ethnographic support. In addition, since scholars (e.g. Brady 1989) have also reported contrary data from other caves, this project demonstrates that ideology and activity patterns within landscape features may vary starkly from region to region among people of the same culture—a consideration that is largely overlooked in the literature.

In addition to material encountered which will help inform the immediate research goals of the project, two surprise discoveries hold promise for future work. First, after excavating below an outstanding stratigraphic sequence of *sascab* floors and cultural material dating back to the Middle Formative in Aktun Kuruxtun, the remains of Pleistocene megafauna were encountered at excavation depths between three and four meters and represent at least one animal from the Artiodactyla order such as a camel or bison. Secondly, a sealed tunnel was discovered in one cave that likely leads to an unexplored chamber that has not been accessible since ancient times. Since it was discovered on the auspicious “last day of the field season” time did not allow it to be fully uncovered and accessed, so it was reburied for future investigation. Its location will remain hidden for purposes of preservation and security until it can be properly studied in a subsequent field season.

In summary, preliminary analysis of artifacts and cave modifications in Central Yucatan strongly suggests a high level of standardization and similarity between the ways that major caves inside and outside of elite architectural complexes were used. Moreover, a consistent pattern of spatial distribution of artifacts has also revealed ways in which various zones within caves were perceived differentially by the ancient Maya. However, other key differences were identified between the caves—notably the frequency with which objects commonly associated with the elite class are found. Though we are fresh out of the field and little detailed analysis and interpretation has thus far been conducted, it is my hope that over the next year continued research and laboratory results will prove fruitful in advancing the research goals of the project to develop a better understanding of ancient cave use in Central Yucatan.

Finally, a humble bow of gratitude to you, the Cave Foundation, for your generous support. I believe CYAC will result in important contributions to the fields of archaeology, anthropology, and karst studies and the Cave Research Foundation played a large role in getting the project off the ground. Many thanks! I hope to have the opportunity to work with your organization again in the future.

# Contributions of Karst Groundwater to Water Quality and Quantity of a Mountain River Basin under Varying Climatic Conditions

The Kaweah River, Sequoia and Kings Canyon National Parks, California

*Benjamin Tobin*

*Ph.D., Texas State University, San Marcos*

## Introduction

Hydrology of Sierra Nevadan rivers is primarily controlled by three mechanisms: rainfall-runoff, snow accumulation and seasonal melting, and groundwater recharge, storage, and subsequent discharge (Bales et al., 2006). Snowmelt and groundwater storage provide temporal distribution of the seasonal precipitation and support stream flows during the annual dry season. The role of snowmelt hydrology in biogeochemical processes and maintaining river discharge has been the focus of numerous studies (Clow et al., 2004; Dozier and Melack 1989; Elder et al. 1991; Marks et al. 1992). However, the extent to which groundwater contributes to discharge and the temporal distribution of water in these systems has not previously been quantified. In the Kaweah River Basin, a mountain river basin in the Sierra Nevada of California (Figure 1), most prominent groundwater systems are karst, with numerous springs flowing out of marble bedrock and over 250 documented caves. In less mountainous areas, karst has been shown to be a significant source of groundwater. To determine if these systems play a significant role in water flow in the Kaweah Basin, field documentation of karst springs in the Kaweah River basin was conducted from 2010–2012. These data were then used to address the questions:

1. What patterns exist in karst water storage in the basin?
2. If springs can be grouped, how do these groups compare?
3. How do these systems behave post-fire? and,
4. What role do these aquifers play in the basin-scale water cycle?

## Research Summary

Funding from the 2010 Cave Research Foundation Graduate Research Grant went towards chemical analysis of water samples and installation of instrumentation to document spring discharge, electrical conductivity, and temperature. Below is a summary of the main findings of this research.

### Documenting Karst Springs in the Kaweah Basin

In this study, we documented the hydrology and geochemistry of 47 perennial karst springs in the Kaweah River (Figure 1, Figure 2). The springs have a wide range of inter- and intra-spring variability in discharge and geochemistry. We assessed variability by performing statistical comparisons of spring chemistry, principal components analysis of all measured variables, and analyses of stable isotope data.

Results show that springs can be divided into two distinct groups: high elevation springs of the Mineral King Valley, and lower elevation springs throughout the rest of the basin (Figure 3). In principal component space, these springs separated based on gradients between positively loaded Calcite Saturation Index values and specific conductance values and negatively loaded relative amounts of calcium and nitrate. Additional separation between the groups showed a gradient primarily between positively loaded alkalinity and negatively loaded chloride and sodium.

Four springs (two from each group) were continuously monitored for discharge, temperature, and specific conductivity. Hydrograph recession analyses showed statistically similar baseflow recession slopes, indicating that there is minimal difference in the nature or type of storage components of the aquifers. The biggest difference between each group is the variability in amount of water remaining in the aquifer during baseflow conditions. High elevation springs have lower baseflows than lower elevation springs, in spite of the fact that more precipitation falls at higher elevation. This difference is likely due to differences in

**Opposite:** Figure 1. Study location with all documented spring sites, continuously monitored springs (1–Big Spring; 2–Crystal Cave; 3–Mossy Spring; 4–Alder Spring; 5–Warm River Spring; 6–Upper Smoking Spring; 7–Monarch Spring; 8–Tufa Spring; 9–White Chief Spring), and precipitation sites. Source: Tobin, BW, Schwartz, BF. 2016. *Using Periodic Hydrologic and Geochemical Sampling with Limited Continuous Monitoring to Characterize Remote Karst Aquifers in the Kaweah River Basin, California, USA. Hydrological Processes, 30, 3361–3372. doi:10.1002/hyp.10859.*

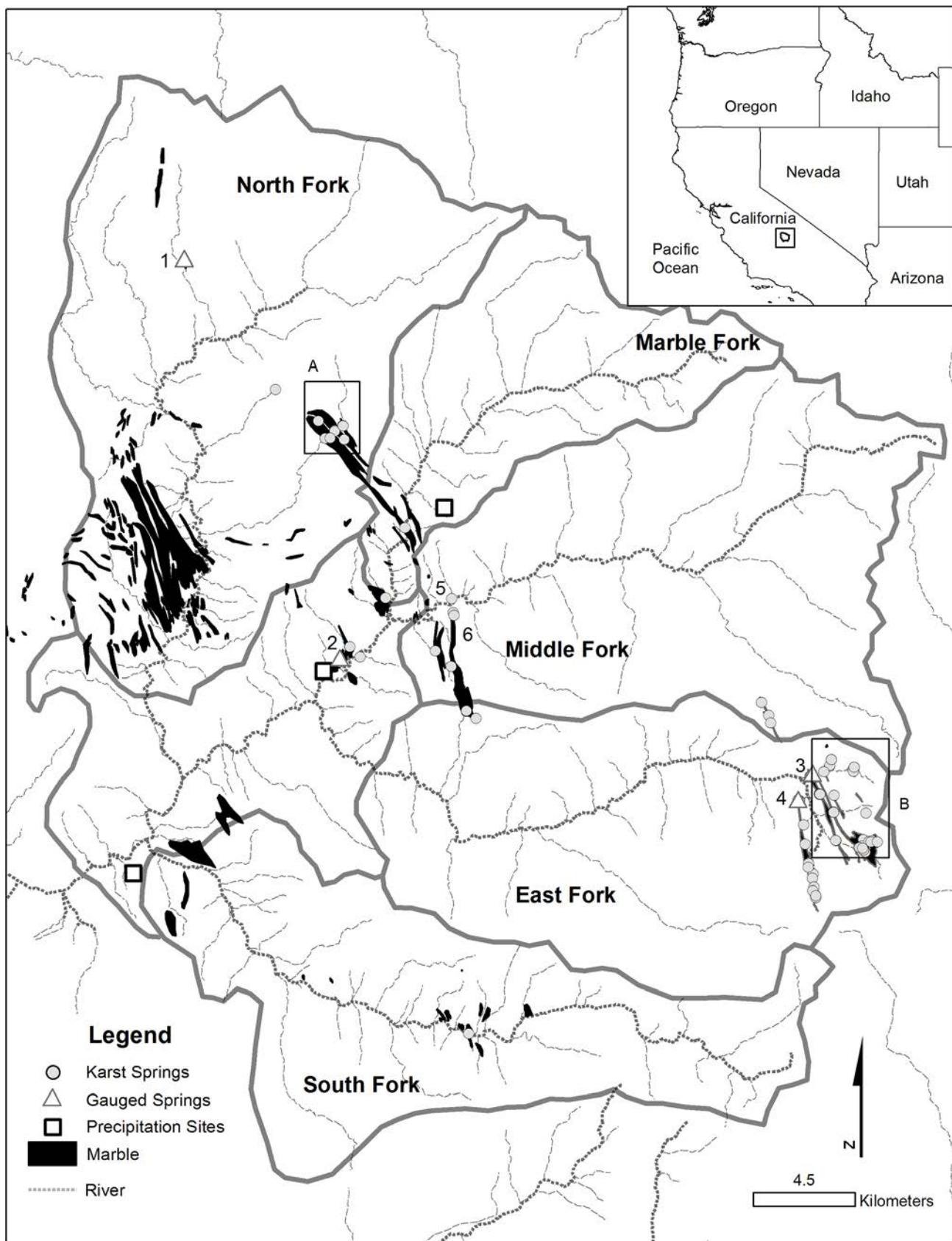




Figure 2. High elevation karst of the White Chief Valley, source of 5 karst springs. Lightest colored rock in lower center of image is marble. Darker rocks surrounding marble are Granite (to the left) and Schist (to the right).

recent geomorphic history: high elevation aquifers were glaciated as recent as 41 kya, while there is no evidence that low elevation springs have been under glacial ice. As a result, lower elevations have developed thicker soils and weathered bedrocks and thus a larger storage capacity for water. A manuscript detailing these results is in progress.

The comparisons of representative springs of these groups, Big Spring and Tufa Spring (low and high elevation, respectively) have previously been published (Tobin and Schwartz, 2012). Additionally, a look at post-fire nutrient dynamics in a karst groundwater-surface water system is in review (Tobin et al., in review).

#### Karst Groundwater and River Discharge

By volume, most water leaving mountain rivers in the western United States is sourced directly from snowmelt (Clow et al., 2004; Dozier and Melack 1989; Elder et al. 1991; Marks et al. 1992), but baseflow is often maintained by

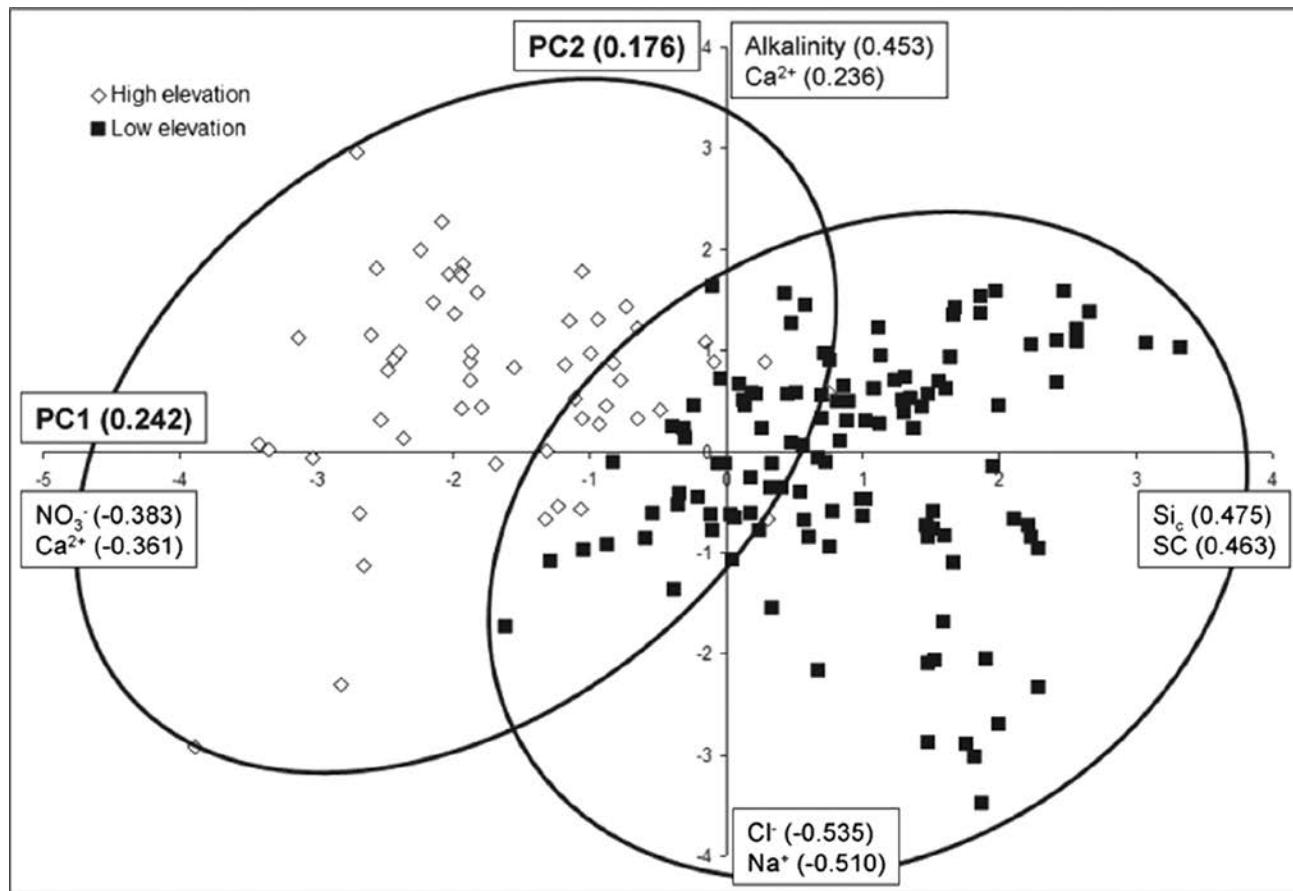


Figure 3. Principal Components Analysis of data for all spring samples. PC 1 represents 24.2% of variability in the dataset, with a gradient between SIC and specific conductance (positively loaded with loadings in parentheses) and nitrate and calcium (negatively loaded). PC 2 represents 17.6% of variability in the dataset with a between alkalinity and calcium (positively loaded) and sodium and chloride (negatively loaded). Source: Tobin, BW, Schwartz, BF. 2016. Using Periodic Hydrologic and Geochemical Sampling with Limited Continuous Monitoring to Characterize Remote Karst Aquifers in the Kaweah River Basin, California, USA. *Hydrological Processes*, 30, 3361-3372. doi:10.1002/hyp.10859.

delayed release from other storage components; primarily groundwater in several types of aquifer systems. Little work has been done to assess the role of karstic groundwater in these mountain systems. To address this question, (1) we directly measured the amount of water discharging from karst springs and compared that to river discharge values, and, (2) following methods of Lee and Krothe (2001), conducted 3-component end member mixing models to determine the relative contribution of karst and non-karst groundwater to river discharge of the Kaweah River and its five forks (North, Marble, Middle, East, and South).

The percentage of total discharge that is derived from karst groundwater in each fork depends on season and the amount of karst present. Measured contributions by karst springs to the North Fork, East Fork, and Kaweah River ranged from 3.5% to 16% during high flow and 20% to 65% during baseflow conditions. The large range is most likely due to variations in the amount of karst present in each basin, with the North Fork having the largest proportion of karst (4.4%) and largest contribution of karst (65% of baseflow in 2012).

End member mixing models produced results comparable to direct-measurements. During low flow conditions, karstic waters comprised a maximum of 79% of discharge in the North Fork, and a minimum of 0.1% in the Middle Fork. During high flow conditions, the proportion of discharge accounted for by karst is lower and ranges from 26% in the North Fork to 0% in the Middle and Marble Forks.

Karst aquifers may be the single most important non-snow storage component in the Kaweah River basin: mapped karst represents just 1.4% of the surface area, but water from karst aquifers represents 8% of discharge during high flow and 48 % during low flow, based on mixing model results. Similar situations likely exist in other Sierran systems containing karst. A manuscript detailing these results is in progress.

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# Cache Caves in South-Central California

A Dating Conundrum

*Wendy Whitby*

*University of Central Lancashire*

This report summarizes my research on the cache caves of south-central California and in particular focuses on the difficulties of dating the artifacts recovered from these caves.

## Background

Dry caves that are scattered across the mountainous Santa Barbara backcountry (Figs. 1 and 2), in south-central California, have yielded an outstanding collection of indigenous artifacts. This is a region where the mountains of the Coastal and Transverse Ranges sometimes rise above 2000m, and the landscape is characterized by sandstone canyons, oak and pine woodlands, and grass covered upland plateaus (*potreros*). Xeric environmental conditions in these dry caves have resulted in exceptional preservation of perishable materials, and the assemblage contains over 800 items such as wooden bullroarers, feather bands, deer bone whistles, large quantities of basketry, arrow-shafts, steatite arrow straighteners, smoking pipes, digging sticks, matting, and bundles of curated plant materials (Whitby, 2012a). The objects are associated with hunting and gathering activities, as well as ritual and ceremonial practices and present a unique opportunity to study aspects of indigenous life in the region over a long time period.

This region was occupied primarily by indigenous people ascribed to the Chumash cultural group, although a southeastern portion was likely occupied by the Tataviam cultural group. This indigenous population of semi-sedentary hunter-gatherers was plunged into turmoil from AD 1769 when the Spanish missionization program heralded the start of the colonial period (AD 1769–late 19<sup>th</sup> century). Over the next hundred years Spanish, Mexican and Anglo-American colonizers dramatically changed the economic, political and ecological landscape of south-central California.

The majority of archaeological studies pertaining to the Chumash have focused on the prehistoric period, mainly considering excavated sites on the Northern Channel Islands or the mainland coastal strip (for example, Arnold, 2004; Gamble, 2008; Kennett, 2005). Most previous colonial-period studies, meanwhile, have concentrated on

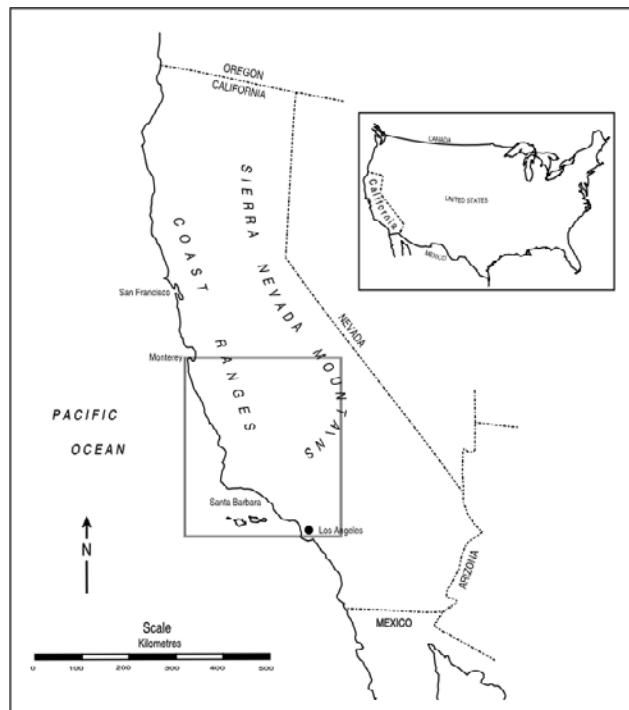


Figure 1

the missions and closely adjacent indigenous sites where colonial influence was strongest (for example, Costello, 1989; Hageman and Ewing, 1991). The Chumash of the mountainous hinterland region are relatively under-studied compared to the coast and Channel Islands, and the Tataviam cultural group remains almost invisible in the archaeological and historic records (Johnson and Earle, 1990:191). The archaeological study of cache caves and their artifacts has thus provided a novel opportunity to address this imbalance and in particular, given that a significant proportion of the material appears to have been deposited in the colonial period, to explore indigenous practices during the turbulent colonial period within the more autonomous context of the Santa Barbara hinterland (Whitby, 2012b).

## Approach

My doctoral thesis (Whitby, 2012a) has provided the first collation of all the data relating to cache cave sites and their associated artifacts in the Santa Barbara hinterland. Prior to this study very little research had been carried out on this important corpus of material or on the cache cave phenomenon. The most significant previous studies were the reports by Elsasser and Heizer (1963), Grant (1964) and Mohr and Sample (1955, 1967) on specific collections of artifacts, and the undergraduate thesis by Gollar (1996). Most of the artifacts are now housed in US museums, although some remain in private collections, and there is one known extant cache cave site. My research thus combined archival and museum studies with a small amount of fieldwork, in order to generate a basic geographic and temporal framework for the use of cache caves. This in turn enabled me to propose models for indigenous caching practices in the Santa Barbara hinterland, and in particular to question processes of indigenous resistance and

acculturation during the colonial period (Whitby, 2012a; 2012b; *in press*)

## Dating

A major challenge for this project has been assigning a temporal framework to the use of cache caves because the recovered artifacts have no stratigraphic association. It is also difficult to use a typological approach because a high proportion of the corpus consists of perishable artifacts that are not normally found in excavations. Lithic artifacts and shell beads are probably the most chronologically diagnostic artifacts found in south-central California, but these artifact types have rarely been found in association with cache caves. There is evidence that at least some of the cache cave material is of relatively recent date. A feather skirt, for example, contains glass beads and textiles (silk and wool), which were only introduced to the region by Europeans sometime after AD 1769. Similarly, a steatite

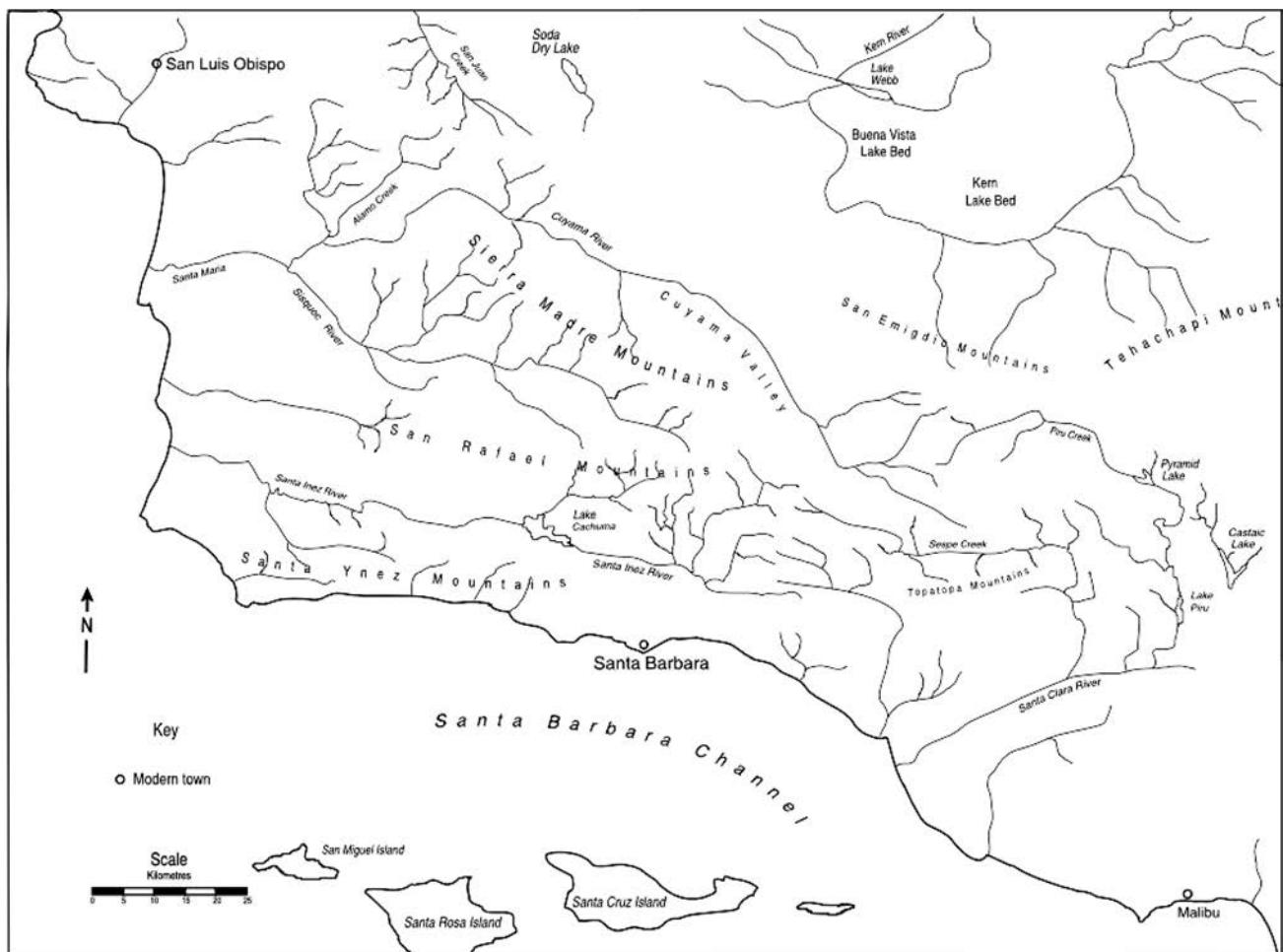


Figure 2

smoking pipe was wrapped in a burlap textile material which could not have been introduced before the historic period. Some of the artifacts, furthermore, have exceptional levels of preservation which would seem to infer a relatively recent deposition and there is a suggestion, based on visual appearance, that some of the wooden artifacts were manufactured using metal tools rather than stone, again pointing to a post-AD 1769 date. A radiocarbon analysis obtained from a recovered basket in the early 1960s suggested a date of 1843 +/- 80 years (Grant, 1964:11), although the minimal information about how this date was determined casts some doubt as to its accuracy. It remains a possibility, nevertheless, that some of the less well-preserved artifacts could be much older. We know that basketry, for example, was being made in this region for thousands of years and may survive for long periods in certain environmental conditions; fragments of woven seagrass were discovered in excavations in Daisy Cave on San Miguel Island, and their dates span the period 9,500–6,600 BC, attesting to the longstanding use of basketry in this part of California (Connolly et al, 1995).

Funding provided by the Cave Research Foundation in a Graduate Research Grant has enabled me to carry out a small program of AMS dating on basketry specimens that had been recovered from cache caves. Dr John Johnson, Curator of Anthropology at Santa Barbara Museum of Natural History, kindly gave permission for samples to be collected from three basketry specimens at the museum. It was desirable to analyse specimens that had an established provenience plus detailed information about the corresponding cache cave. In order to avoid contamination that might produce a false AMS date the number of basketry specimens that could potentially be analyzed was actually quite limited. Much of the basketry recovered from cache caves has been coated with asphaltum; a deliberate indigenous practice that is common in this part of California in order to produce watertight vessels for cooking or water carrying. Some of the baskets recovered in the 1930s were also treated with resin after their recovery, a common archaeological practice at the time in order to help conserve the specimens. In the latter half of the 20<sup>th</sup> century, museums in the USA also commonly applied organic pesticides to basketry and other perishable objects. The three specimens were thus selected to avoid the above contamination issues and to provide a geographic spread in terms of site location. The samples were analyzed by the University of Oxford Accelerator Unit using procedures described in Bronk Ramsey et al (2002; 2004a; 2004b). Calibration plots were generated using the Oxcal computer program and the INTCAL09 dataset (Reimer et al, 2009).

The AMS results that have been obtained from the basketry (to be published in a forthcoming paper by Robinson et al) span the early 1<sup>st</sup> millennium AD through to

the historic period and thus indicate that the indigenous practice of caching in caves did indeed extend over a long period of time.

## Outcome

My research has proved the longevity of indigenous caching practices in the mountainous Santa Barbara hinterland. I have also been able to propose different types of caching behavior, with geographic and temporal trends, and relate this to indigenous value systems. Forthcoming publications will expand on these findings in more detail.

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