Cave and Karst Programs

Geologic Resources Division
National Park Service
U.S. Department of the Interior

Inside Earth

Fluorescence in broken speleothems, a study in luminescence at Coronado National Memorial. Photo by Stephanie Kangas.

Contents

A Word from WASO

Calendar

The 23rd International Conference on Subterranean Biology
June 13-17, 2016
Fayetteville, Arkansas
http://www.speleobiology.com/icsb2016/

Bat Survey Techniques Workshop
July 10-17, 2016
Tulelake, California
www.batmanagement.com

NSS 75th Anniversary Convention
July 17-23, 2016
Ely, Nevada
http://nss2016.caves.org/

Timpanogos Cave National Monument Restoration Camp
September 8-10, 2016
American Fork, Utah
andy_armstrong@nps.gov

Geological Society of America Annual Meeting
September 25-28, 2016
Denver, Colorado
http://community.geosociety.org/gsa2016/home

NSS Convention
June 19-23, 2017
Rio Rancho, New Mexico
https://www.facebook.com/2017-NSS-Convention-854647214625996/info

Submit entries for the Calendar to bonny_armstrong@nps.gov

To receive this newsletter and pertinent updates and announcements, join the NPS Cave and Karst listserve here:
http://nature.nps.gov/GEOLOGY/caves/email_info.cfm

HIGHLIGHTS OF THE NATIONAL CAVE AND KARST PROGRAM

by Dale L. Pate

Junior Cave Scientist Program
This important educational program has been a great success for its first year of development and release. The Junior Cave Scientist activity booklet remains very popular with all 19,500 copies of the 1st edition distributed. During this first year, these booklets have been sent to parks, schools, other organizations, homeschoolers, and individuals within 41 states, Washington DC, Guam, Canada, and Australia. Not to worry though, a 2nd updated edition is now in the works and we should have printed copies in the next few weeks. Of special note, we welcome the US Forest Service, Cave Research Foundation, and the National Cave and Karst Research Institute as partners and sponsors of this program. We hope to add more agencies and organizations as we move forward with this program. Meanwhile, you can still download an electronic version of the booklet at: go.nps.gov/jrcavesci

Scientific Integrity
In recent years, scientific integrity has come to the forefront when management and policy decisions are made. In 2012, the NPS issued policies concerning scientific integrity as a guide for NPS employees and its many partners. For many, a course on Scientific Integrity through DOI LEARN has been required training this year. Taking the time to review these policies is well worth the effort. For those who may have missed the training, you can download Director's Order #79: Integrity of Scientific and Scholarly Activities at the following link: https://www.nps.gov/policy/DOrders/DO_79.pdf

Dale Pate, NPS National Cave and Karst Coordinator. Photo by Johanna Kovarik.

Cave and Karst Summaries
Summaries of cave and karst resources found in the many park units remains a priority for our work load at the national level. Thanks to the work of Melisa Bishop, our current GIP Guest Scientist and Limaris Soto, a past GIP Guest Scientist, we have more than 60 draft cave and karst summaries. These draft summaries have been used to help the Geologic Resources Division (GRD) provide accurate up-to-date information to the many parks that hold Foundation workshops and develop a Foundation document for their park. Our goal is to also make final summaries available on our National Cave and Karst Website. This has been a slower process, but we are making progress with summaries soon to be completed for Mammoth Cave National Park and Big Bend National Park. You can find a few completed summaries on our website. https://www.nps.gov/subjects/caves/cave-karst-publications.htm

Shared Karst Landscapes Reports
In most cases, NPS properties

contain portions of a much larger karst landscape. With the initiation of these types of reports, we can begin to better understand and manage these complex landscapes. These reports will provide: (1) an overall snapshot of what is collectively known; (2) determine critical information needed to complete our understanding of these shared landscapes; (3) provide recommendations for future research; (4) identify potential vulnerabilities from anthropogenic surface activities, and (5) provide a framework for future planning efforts designed to induce long-term protection for our shared karst landscapes. To begin this effort, Melisa Bishop has been developing a Shared Karst Landscape Report for Cedar Breaks National Monument in conjunction with the USFS to better understand groundwater movement in karst watersheds in and around the Monument.

Items of Interest

Luminescence in Coronado National Memorial

by Stephanie Kangas

Abstract

The impurities in the water that formed the speleothems within the Coronado National Memorial's cave system have left quite a display for an explorer with the right tools. Shining an ultraviolet (UV) light on the dark cave walls will illuminate them, exhibiting colors ranging across the visible spectrum in a process of electromagnetic radiation. The unique geology of the Memorial provides a plethora of potential ions capable of absorbing the UV energy and re emitting energy in the form of fluorescence. There are several ions capable of this awe-summoning reaction including Mn2+, Pb2+, tungstates, Fe3+ , rare earth elements (REE's) and organic compounds [2,3,5,11] potentially incorporated in the growth of the speleothem. Laser stimulated fluorescence and its spectral analysis provides a new portable, affordable way to perform long distance, nondestructive geochemical analysis of caves. Cave formations are a precious and fragile natural resource. This approach uses manageable gear and photography to extract information, while still protecting the intact formations and the cave environment as a whole.

Introduction

Fluorescence, in essence, is a non-thermal UV radiation displayed as visible light [11] (See cover photo). The process involves the presence of atoms capable of both absorbing and re-emitting the light [9]. For this to be possible, there must be radiation-induced luminescent centers with appropriately spaced electron configurations that allow stimulation via UV photons to migrate the electrons to 'excited states' [9, 11]. This excited and unstable electron will immediately lose some energy to internal conversion (vibration) and then return to its ground state as it stabilizes, emitting the remaining energy as photons with wavelengths equal to the initial UV minus the energy lost in kinetics[9,11]. Lower quantum efficiency would create a larger difference between the absorbed wavelength and the longer wavelength reemitted. The intensity and hue of the fluorescence is a product of the wavelength of light introduced, any filters, and the fluorescent properties of the specimen, [7] including activating ions present and their quantum efficiency.

The job of absorption and reemission isn't always done by the same contaminant. One of the most common activators in calcite is divalent manganese, which is commonly known to fluoresce an orange-red color. The manganese often works with co activators to absorb the UV and transfer the energy over to Mn2+ for emission. These co-activators are most commonly Pb2+, organic impurities, and REE's [1]. Laser induced spectroscopy and X-Ray Fluorescence (XRF) analysis creates a basis for potentially

Left to right: Stephanie Kangas, GeoCorps/GIP; Tom Kaye, local Spectroscopist; Jessica Garcia, GeoCorps/Guest Scientist.

identifying peak in wavelengths and discriminating between activating ions.

Geochemistry of Coronado National Memorial is a unique area geologically. Paleozoic limestone metamorphosed into marble and dolomite, surrounded by interbedded sandstones and silt deposits, generally encased in quartz monzonite. These caves were recrystallized in the Mesozoic era, in close proximity to a variety of ions that aren't common in many other locations. Increased faults and fractures at these locations have implications for sub-surface water travel. There are confirmed tungstates and sulfates as well as the standard carbonates in the area, which could have been exploiting these natural and anthropogenic structural features.

Calcium carbonate, the main component of caves, is known to have the largest variation on potential radiation centers, but some of the most common fluorescent contaminants are Mn2+, Pb2+, Ce2+, tungstates, Fe3+ , rare earth elements (REE's) and organic compound [2,3,5,11]. According to Baseline Water Quality Data Inventory and Analysis for Coronado National Memorial conducted by the Water Resource Division and Service wide Inventory and Monitoring Program sampling event (2000), several wells within the park show sulfate, beryllium, cadmium, copper, lead, selenium, silver, thallium and zinc concentrations well above EPA standards, which have the potential to yield interesting results.

These caves exhibit mineralogical diversity. Slightly metamorphosed caves are known to have both fluorescent and non-fluorescent minerals, like calcite and its polymorph aragonite, dolomite, epidote, vesuvianite and small garnets. Coronado's unique location gives it the potential for more rare minerals, including willemite, rhodochrosite and scheelite.

Data collection

Cave instruments include a 405 nm laser mounted on an electric rotator attached to a 12v battery and a Nikon D610 with a yellow filter, which is used to remove as much of the UV light as possible (see photo 2). A second spectrum filter is fixed atop the yellow filter, to project the spectrum of the material excited by the laser. The camera must be mounted on a tripod to ensure clear pictures- since photography in the dark requires a long exposure time and a high aperture setting [7]. The laser stimulated photography can be captured from as far as 50 meters.

Multiple caves were photographed in this analysis. There was a clear distinction between the original cave walls and the later mineralization events (see photo 3). Within these events, distinctions could be drawn in hue, implying changes in the water chemistry. Without the fluorescence, these events are indistinguishable. With the photographs, and some color balance editing, these changes in ion availability are quite obvious. In addition to fluorescence, there was also evidence recorded of laser stimulated phosphorescence.

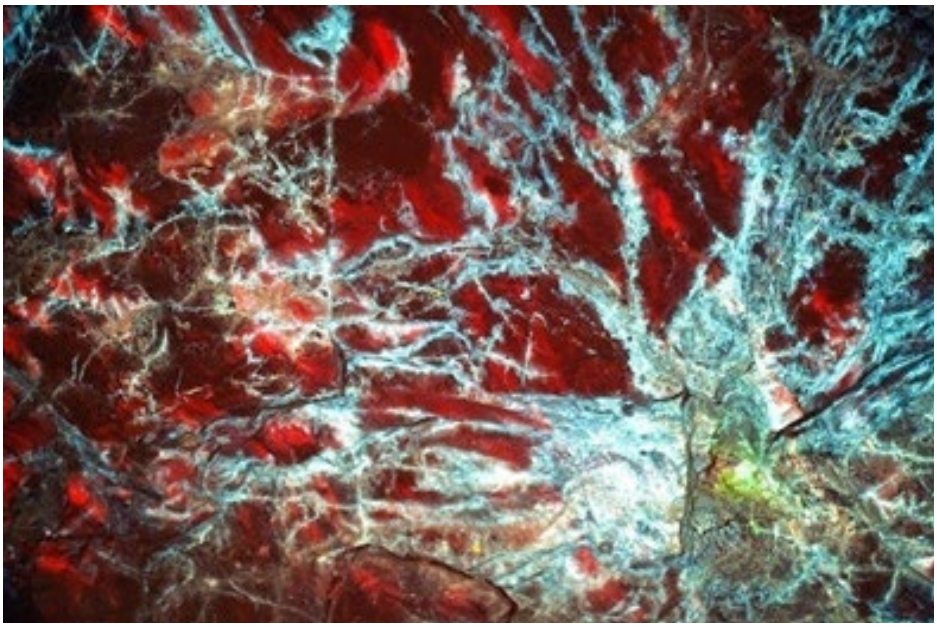
Field samples were analyzed and compared with XRF and visible spectrum data to improve confidence in spectral peak identification. The samples were analyzed with a scope and 405 nm laser with Ocean Optics Visible Spectrum software to locate and isolate the fluorescence before XRF analysis. The data was collected with an XRF at 15KV then analyzed with

Members of the GeoCorps/GIP program adjusting laser and camera.

Minipal/Minimate software to determine the ions present in fluorescent and non-fluorescent pieces to identify elements that correlate with the fluorescent contaminants.

Results

A single mineral sample can display different fluorescent reactions under shortwave UV, longwave UV and blue lights [11]. In this study, the 405 nm wavelength was used for consistency in simulating fluorescence and recording spectrums in the cave. In addition to the laser, XRF analysis was done to more confidently identify potential fluorophores. Regardless, we were still able to photograph fluorescent colors across the spectrum, in addition to phosphorescence on one of the cave walls!



Host rock with secondary mineralization. Photo by Tom Kaye.

The red/orange/pink fluorescence was expected to have higher concentrations of manganese, while the other blues and greens were expected to have more REE's or organics. These were more difficult to analyze, due to collection restrictions for preservation.

The XRF reinforced the suspicion that Mn2+ was substituting for Ca2+, in most samples. However, Mn2+ on its own has a small probability of absorption, which implies that in a sample that has dominantly Ca2+ and Mn2+ there is likely a third activator or synthesizer we have yet to identify [11]. Pb 2+ is often in this role, but there were no significant levels detected in the spectrum or XRF, although it does have a potential to provide this function even in very small concentrations [5]. The intensity of fluorescence may have also been affected by the presence of quenchers in the samples from inside and near the cave, like divalent manganese and copper.

To increase confidence in these results, a dissolution method was used to determine whether or not organic matter was responsible for the fluorescence. Organics are common activators, because the acidity of cave water promotes the disassociation of carboxyls giving speleothems a surface net positive charge [12]. This makes them ideal surface for absorbing the organic material in the water. This, however, does not appear to be the case at Coronado.

Conclusions

Spectral analysis can provide some evidence in rates of change within speleothems. It has implications for tectonic interference when considering water sources as epithermal solutions vs. surface water [13], as well as indications for changes in surface water sources, water quality and other potential Quaternary climate indicators.

This technique is still in its emerging phase, with many avenues to explore. As a result of advancements in technology, medium-power shortwave and longwave lasers are becoming more accessible to researchers for multiple applications [7]. It is non-invasive, comparably affordable, and provides new data and insight to speleogenesis and formation sequences. At this time it is still unknown how to investigate multiple/co-activators or organic material present, but it is worth further investigation.

Acknowledgements

This wouldn't have been possible without Tom Kaye. The dedication of time filled with enlightening and inspiring discussion. His input was essential for this depth of an analysis of the Coronado National Memorial Caves. Thank you, Tom, for access to your portable cave fluorescent/photography equipment, analysis software, and the use of your lab.

References

[1]Barmarin, Gerard. "Calcite." Database of Luminescent Minerals. (2010). Fluomin.org/uk/fiche/php?id=157.

[2]Beynen, Philip Van, Rick Bourbonniere, Derek Ford, and Henry Schwarcz. "Causes of Colour and Fluorescence in Speleothems." Chemical Geology: 319-41. Print.

[3]Bozlee, Brian J., Anupam K.

Misra, Shiv K. Sharma, and Melissa Ingram. “Remote Raman and Fluorescence Studies of Mineral Samples.” Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy: 2342-348. Print.
[4]Fosbury, Robert. “Fluorescence Spectroscopy of Minerals: 1- Using a Spectrometer.” The Fluorescenct Mineral Society (2013):5-17. Online.
[5]Gaft, M., L. Nagli, G. Panczer, G. Waychunas, and N. Porat. “The Nature of Unusual Luminescence in Natural Calcite CaCO3.” American Mineralogist (2008): 158-67. Print.
[6]Johnsen, Ole. Minerals of the World. Princeton, N.J.: Princeton UP, 2002. Print.
[7]Kaye TG, Falk AR, Pittman M, Sereno PC, Martin LD, Burnham DA, et al. (2015) Laser-Stimulated Fluorescence in Paleontology. PLoS ONE 10(5): e0125923. doi:10.1371/journal.pone.0125923
[8]Lynch, Bob, and Dan Lynch. Rocks & Minerals: A Field Guide to the Grand Canyon State. Cambridge: Adventure Publications, 2010. Print.
[9]Matzel, Charles, and Earl Verbeek. “Fluorescence of Minerals under Blue Light.” The Picking Table 55(2014):13-25. Print.
[10]Pough, Frederick. Rocks and Minerals. Fifth ed. New York: Houghton Mifflin, 1996. Print.
[11]Rakovan, John, and Glenn Waychunas. “Luminescence in Minerals.” The Mineralogical Record 27 (1996): 7-19. Print.
[12]Ramseyer, Karl, Teodoro M. Miano, Valeria D’orazio, Andres Wildberger, Thomas Wagner, and Jörn Geister. “Nature and Origin of Organic Matter in Carbonates from Speleothems, Marine Cements and Coral Skeletons.” Organic Geochemistry: 361-78. Print.
[13]Shopov, Yavor Y. “Luminescence of Cave Minerals.”Boletin de la Sociedad Venezolana de Espeleologia 35(2001). Online.

Park Updates

Buffalo National River

Submitted by Kayla Sapkota

Cave Research Foundation activities in Buffalo National River have gotten off to a productive start in 2016, with over 30 trips focusing on biological monitoring, cave inventory, and cave survey objectives. Fifty new cave and karst features have been documented, and over 700 hours have been volunteered. Research facilities and equipment improvements have aided in our efforts to expand our volunteer base and host larger groups, producing greater results. Additionally, we have been diligently working to extract any faunal data from existing paper reports, dating as far back as the 1960s, in order to create faunal entries in the current Buffalo National River Cave Database.

Carlsbad Caverns National Park

Submitted by Rod Horrocks

Cave Exploration, Survey & Cartography
Lechuguilla Cave
In November of 2015, Max Wisshak led a nine-member climbing and survey expedition on a seven day trip to the South Winds, Southern Climbs, LeBarge, Deep Seas, and Deep Secrets areas of Lechuguilla Cave. This turned out to be the only survey expedition in Lechuguilla during 2015. They were able to survey 5,300 feet of new passage and resurvey 2,300 feet of problem surveys. They made good progress in wrapping up the South Winds and Southern Climbs Quadrangles. In that area, they found a tight vertical fissure that

Cave harvestman in Tom Barnes Cave. Photo by Matt Bumgardner.

linked to a boneyard area, where they surveyed 800 feet of new cave. They also nearly finished the Lebarge Area Quadrangle, continuing their work in the Neuland area with its gypsum chandeliers and climbs. They were able to complete a three-day aid climb up a 200-foot high dome that dead-ended, which they named the Polar Circus. A climb up another dome, named the "Diplomacy Dome", led to mid-sized borehole and adjacent boneyard maze that was surveyed for 900 feet.

Carlsbad Cavern
Derek Bristol led six cavers on a 4-day expedition to the Chocolate High and Guadalupe Room Sections of Carlsbad Caverns. In the Chocolate High area, they photographed an area called Southern Splendor, an area that had been recently re-found after being lost for nearly 30 years. They also surveyed a lead that went a few hundred feet off the edge of the map, but unfortunately ended. In the Hall of the White Giants area, they surveyed some deep pits that connected to a lower level and then mopped up leads throughout that section. They surveyed a total of 3,750 feet of new survey, raising the length of the Carlsbad Caverns survey to 32.35 miles.

Beaded helicites in the newly re-found Southern Splendor area in Carlsbad Caverns. Photo by Derek Bristol.

Spider Cave
Paul Burger has continued to lead survey trips into Spider Cave. He has been able to fix all of the problem loops in the historic portion of the cave and to survey additional leads in the Gilead section in the north part of the cave.

Slaughter Canyon Cave
In April of 2015, Dave West led a multi-day CRF expedition to continue checking leads in Slaughter Canyon Cave, surveying them when warranted. They used ladders to access many of the high leads. They are nearing completion of their survey project, with only tight or wet leads remaining.

Cave Restoration
Over Presidents Day Weekend, William Tucker of the Cave Research Foundation led five cavers in a project to clean red clay out of some pool basins in the Big Room of Carlsbad Caverns.

Cave Research Activities
Like most NPS cave parks, Carlsbad Caverns received funding in FY2016 for projects related to bats and WNS. With the bulk of the funding, the park is finalizing an agreement with Diana Northup and Debbie Buecher to continue their microflora analysis of Myotis species by swabbing the skin and fur of captured bats. The project will also include additional soil and

substrate sampling to test for the presence of Pseudogymnoascus destructans.

In May of 2016, David Levy sampled five drinking water pools located in Lechuguilla Cave. The parameters he sampled were pH, conductivity, dissolved oxygen, and temperature. He sampled Underground Atlanta, Lake Margaret, Lake Lechuguilla, and the FE44 pool. The results from this sampling were added to the Lechuguilla Cave Water Quality Database.

Dr. Andreas Pflitsch is continuing his climatological research at Devils Springs, Kings Palace Lower Cave, and the Left Hand Tunnel in Carlsbad Caverns.

Park Filming
Rod Horrocks took Al Roker from the Today Show, on a tour of Carlsbad Caverns as part of their on-going series highlighting national parks. The results from their filming aired during a four-minute segment on 5/10/16.

Relighting Project
Rod Horrocks completed a work detail last summer in the park in order to design a new LED lighting system for Carlsbad Caverns. He placed, aimed, and rendered around 1,100 lights on the Main Corridor, Kings Palace, and Big Room Tour routes during a four and a half month period. The new lighting system departs from the Ray Granald lighting design concept from 1974. The new system is a feature-based system that highlights individual and groups of related features using texture, contrast, shadows, and color in order to create visually captivating scenes. He also uses blackness to evoke mystery in pits and side passages. With this new design, Rod concentrated on lighting famous, geologically interesting, and visually captivating features. About 30% of the newly lit features were never lit in the past. The new LED lights are remotely controlled using a radio controller and a laptop in order to individually set the intensity and color temperature of each light. The tremendous flexibility of the new lights allowed a uniformity of design and color balance of the whole system that previous cave lighting systems couldn't achieve. The new system, which has reduced the power bill by 85%, will be completed this June.

Ellen Traunter, the new Physical Science Technician at Carlsbad Caverns National Park is seen here working on the new LED lighting system in Carlsbad Caverns. Photo by Rod Horrocks.

Cave Resources Office Staffing Changes
The Cave Resources office has experienced a complete change of personnel. Stan Allison recently transferred to the BLM, where he has accepted a Cave Management position working with Jim Goodbar. After a stint of 17 years at Wind Cave National Park, Rod Horrocks was hired into the park's vacant Cave Management Specialist position, replacing Dale Pate, who left the park four-years ago for the National Coordinator position. Rod recently hired the first of two Physical Science Technicians into the cave resources office. Ellen Trautner accepted that first position and the second will hopefully be advertised and filled soon.

El Malpais National Monument

Submitted by Laura Baumann and Eric Weaver

Cave Invertebrates

The invertebrates in the lava tubes and moss gardens of El Mapais National Monument (ELMA) are some of the most unique species found in the park. They are often overlooked in favor of more picturesque geologic features and animals, but they serve an important role in cave ecosystems and have the potential to provide valuable insight into ecology and evolutionary biology.

The lava tubes have created isolated systems where the biota have been left largely undisturbed for thousands of years. As the creatures inside them become increasingly adapted to the cave environment they begin to evolve to fit that location. This is known as allopatric speciation- a geographic separation of two populations by a feature, such as a cave, causes two distinct species to develop over time. With multiple cave systems located in ELMA, the potential for endemic species is high. It is reasonable to assume that there are creatures in each system that occur nowhere else on the planet. One study done at the park by J. Judson Wynne (2013) found seven new species in just a few weeks of searching. Three of these new species were troglobitic - completely dependent on the cave environment.

Cave invertebrates fill many roles in the cave ecosystem. Along with fungi and bacteria they are the decomposers and recycles of organic and inorganic materials that come into caves. They eat and break down bat guano, plant matter, and dead animals. These organisms are steadily eaten up by increasingly larger invertebrates until the apex predator is reached. In the caves at ELMA the apex predators are typically spiders or centipedes, who may also be eaten by primary surface predators such as birds, bats, and ring tail cats who also frequent the caves.

Cave ecosystems are very sensitive. The systems are often very stable in terms of climate and rarely see disturbance. This means that most of the cave-dependent species are unprepared to handle changes caused by interference from the outside world. The dark zones of caves experienced little interaction with the outside world until humans arrived with artificial lights. In order to allow visitors to access caves, proper measures must be taken to protect fragile ecosystems and the life they support. The most important invertebrate habitats in ELMA caves are moss gardens, mud floors, and curtains of roots that protrude from cave ceilings. Currently, none of our visitor-use caves have significant roots, but each of our visitor-use caves have either mud floors or moss gardens.

Mud Floors

One of the most significant mud rooms at ELMA is found in Junction Cave, our most heavily visited cave. The mud room had been chained off to dissuade visitor entry into the area, but important habitats are believed to exist before the chain is even reached. Natural Resources staff, Eric Weaver (Cave Management Specialist) and Laura Baumann (Biological Technician), built a trail into the cave that guides visitors away from sensitive cave features and avoids mud floors and other significant animal habitat. A similar trail was built in Xenolith Cave to steer visitors away from the mud floor at the entrance, which appears to many visitors as the most enticing walkway.

A centipede crawls through the lava rock in one of El Malpais's caves. NPS photo.

The trails were created in Spring 2016 using stainless steel strips. The trail markers have a reflective red sticker leading into the cave and a reflective white sticker leading out

of the cave. Pliable 20 gauge strips of stainless steel were preferable to rigid pre-bent steel markers because they were easier to place, more adaptable, more economical, and often more stable.

Moss Gardens

Around 80 of our caves have moss gardens growing in their entrances and skylights. Often the moss gardens are as unique as the invertebrates living inside them. The moss is heavily dependent on the cave environment to create a particular microclimate. While the weather outside the cave is continually changing, the cave provides a stable source of cool humid air for the moss. Some species of cave moss found in our Pinyon/Juniper-Ponderosa forest have been classified as alpine and sub-alpine varieties, likely supported by their association with perennial ice caves that stay 30 degrees and humid year-round.

Our first step in protecting these resources was to rope off the areas that are open to visitors and can be easily trampled and destroyed by misplaced footsteps. While we can work to protect the moss from some types of damage, we are concerned about the impact of climate change on the moss. We have observed a 3 degree increase in surface temperatures at ELMA and the loss of perennial ice in many of our caves suggests that the temperature and humidity in the caves are being greatly changed by surface changes. While it is concerning to lose the ice and the paleo-climate data it has been collecting since the late Pleistocene/early Holocene, the change in cave climate will in turn effect the microclimate of the moss, and eventually put sensitive and unique invertebrates in danger.

While it is difficult to mitigate against global climate change at a local level, it is essential that we inventory and monitor features like moss gardens in order maintain a record of their presence and how they are affected by a changing climate.

On May 21 & 22, the Southwest Regional was held to assist in photo monitoring the 80 moss gardens at ELMA. The Southwestern Region of The National Speleological Society provided 17 experienced cave surveyors for a total of 250 volunteer hours to assist in photo monitoring some of the moss gardens in the park. Our photo monitoring protocol was newly developed and their expertise was critical in mapping the moss gardens and troubleshooting placement of photo monitoring stations.

This lush moss garden is situated at the mouth of a large perennial ice cave. NPS Photo.

Modified cave survey techniques were used to create a map of the area, the locations of camera stations and photo points, and the rough extent of the moss. Two techniques were tested to create the photo monitoring stations. The first technique involved placing camera points around the perimeter of the garden and taking pictures focused on photo points within the moss until the entirety of the edges were captured. Unfortunately, the moss gardens are mosaics of dense and patchy areas which causes edges to be less defined than anticipated in the planning stages. An alternative technique was used on the second day to attempt to mitigate this issue. Instead of attempting to capture the entirety of every garden, 3ft by 3ft plots were set out in representative areas of the moss garden and photos were taken above and from the side. This allowed us to get more detailed pictures that showed the complexity of the gardens. We are still sorting through data in an attempt to finalize a protocol for future monitoring.

We hope to continue to improve our visitor-used caves at El Malpais so that visitors can appreciate and learn about these fragile environment while providing greater resource protection. We have many backcountry caves that need to be mapped and inventoried so that we can be aware of the resources they contain and be aware of any threats to them. We hope that with the help of experienced volunteers, such as those through the National Speleological Society, we will achieve our goals.

Great Basin National Park

Submitted by Gretchen Baker

Cave Management Plans
Great Basin National Park is working on two cave management plans: Lehman Caves and Wild Caves. Both are in draft stages. They will be discussed at the 2016 NSS Convention in the closed NPS session Thursday morning and also at the Caves and Karst Management Session Thursday afternoon.

2016 Lehman Caves Lint Camp Report
About 25 volunteers gathered for a weekend in January for the annual Lehman Caves Lint and Restoration Camp. Participants dusted lint from the Gothic Palace to the Lodge Room. Primary areas for restoration included the Gothic Palace, Inscription Room, and Cypress Swamp. Lampenflora was also cleaned near numerous lights. Reporter Ross Johnson from The Ely Times wrote a nice article.

The 1928 "Fairy Garden" is now called the Cypress Swamp, and a trail crosses this area to access the Grand Palace. Check out the exhibition in July to see how places in the cave have or haven't changed in 88 years. NPS photo courtesy of Great Basin National Park.

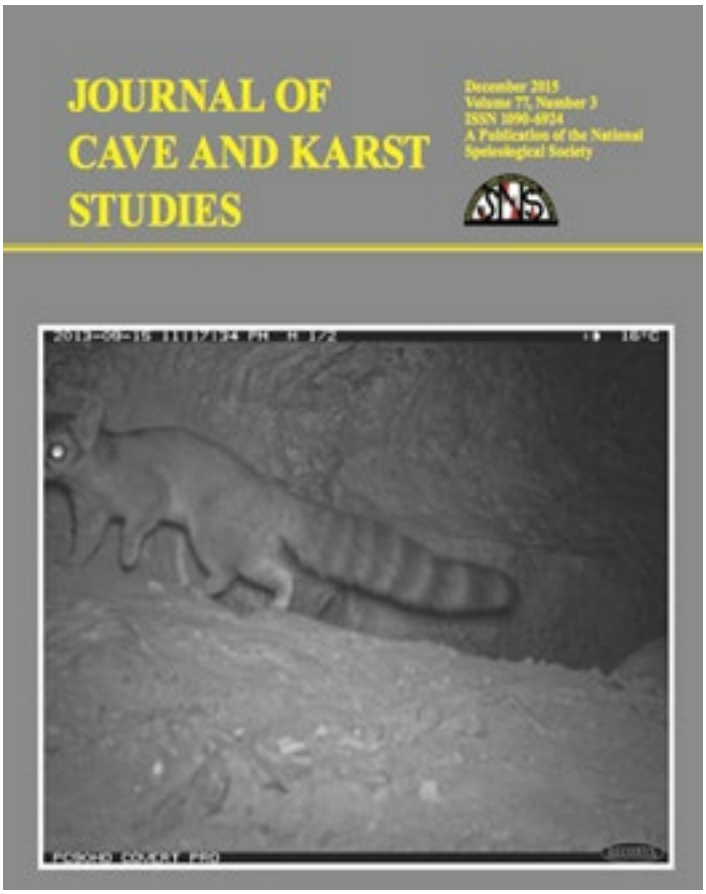
Newly uncovered rimstone dams in the Gothis Palace. They had been covered up for decades, and now, everyone can enjoy them! NPS photo by Gretchen Baker.

1928 Lehman Caves Photos Compared to 2016 Photos
Two years ago, NSS cavers were at the Library of Congress and found forty photographs from Lehman Caves taken in 1928 by John and Mary Walker. They were allowed to take cell phone photos of the historic photographs and share them with Great Basin National Park. The park did not have the photos on record, and in 2015 paid for the Library of Congress to scan them and send the digital files. The photos were taken throughout the tourist trail of the cave.

How has the cave changed in about 90 years? Cave photographer Dave Bunnell came to the cave to rephotograph the same locations. Side-by-side comparisons will then be mounted for display at the Art Bank in Ely during a special exhibition to open on July 16 with a special event from 4-9 pm. John and Mary Walker's grandson is planning to attend. Following the Convention, the exhibit will be available as a traveling display.

Rock the Park Visits Little Muddy Cave in Great Basin National Park
In December, the reality TV show

Continued on page 14 . . .


JOURNAL OF
CAVE AND KARST
STUDIES
December 2015
Volume 77, Number 3
ISSN 1090-6924
A Publication of the National
Speleological Society

Opposite page, clockwise from upper left: Kenny Akers monitors a remote cave in BUFF, photo by Kayla Sapkota. The cover of Journal of Cave and Karst Studies, volume 77, features an image caught by a GRBA camera trap. The entrance of New Cave in Buff, photo by Brandon Van Dalsem. This page, clockwise from top: GRBA 2016 Lint and Restoration Camp participants, NPS photo by Gretchen Baker. High school volunteer Victoria Schleh records data while NPS ecologist Kim Houf swabs the substrate at Round Spring Cavern, photo by Scott House. Meramec Valley Grotto/CRF volunteer Alicia Wallace monitors a cave, photo by Jim Ruedin. Stage two of the decon process at Powder Mill Research Center (stage one involves cleaning off the mud outside) involves a solution splash before washing, photo by Scott House.

Rock the Park came to the park. They filmed a summit attempt up Wheeler Peak and then wanted to go underground. They took a tour of Lehman Caves, but what they were really interested in was the adventure part: squeezing through a wild cave. They obtained a recreational permit for Little Muddy Cave and filmed footage of themselves installing some data-loggers for a cave climate change study (they were happy to be put to work!). You can see the whole episode at Hulu: www.hulu.com/watch/929544

The Behind the Scenes clip from camera man Ray's viewpoint is also interesting: https://www.facebook.com/RocktheParkTV/videos/1285020341525714/

What Animals Use Cave Entrances?
The article "Quantifying wildlife use of cave entrances using remote camera traps" was published in the December 2015 issue of The Journal of Cave and Karst Studies.

Digital infrared remote camera traps were placed at the entrance of twelve caves in Great Basin National Park, Nevada during the summer of 2013 to assess the wildlife use of cave entrances. Surface use of caves is a major nutrient source for cave organisms that spend their entire lives underground. Cave entrances varied in size (0.9-50 m2), cave length (10-1000 m), surface habitat (riparian versus pinyon/juniper), and management approach (gated versus no gate). Data from eight cave entrances is presented with four other entrances removed from the analysis due to equipment failure. The cameras were deployed for a total of 372 trap days, with an average of 46.5 days per cave (range 28-62). The cameras captured 632 trap events, with separate events defined as more than an hour apart for the same species. Of the seventeen taxa documented, the most abundant species photographed were mice, chipmunks, humans, woodrats, and squirrels. Other species observed in cave entrances were cottontail rabbits, bats, skunks, foxes, insects, birds, and domestic dogs. Wildlife entered and exited caves most frequently between 1800 and 0600. Very little information has previously been documented about fauna using cave entrances, and this non-invasive, repeatable technique can help managers learn more about the dominant species using the entrance and twilight areas of the caves they manage as well as peak use times.

The article is available for free from: https://caves.org/pub/journal/Journal_of_Cave_and_Karst_Studies_volume_77.shtml
(It's the last article in the list.)

Jewel Cave National Monument

Submitted by Dan Austin

Cave Exploration and Research
Discoveries in the western branch of the cave have continued to keep volunteer cavers and park staff busy for the past year. First found in March, 2014, the Southwest Splinter has since led to nearly 10 miles of new passages, trending to the south along the western edge of Hell Canyon. West Camp was established in November, 2014 to facilitate trips to the newly discovered section of cave, dubbed the "Splinter" section. Since November 2014, there have been 9 successful camp trips that have utilized the new camp site, including an overnight management trip.

Surveying in the Splinter section has proved challenging in a couple of aspects. As cavers have continued to push the passages to the south, round-trip travel time to the end of the cave from West Camp has steadily increased to 8 hours, making trips to the end much more difficult. Additionally, until recently, lack of available water in the Splinter section forced cavers to carry all of their water supply from camp, making cave packs heavy and cumbersome.

In 2015, a new discovery was made that paved the way for some dramatic changes both with the cave exploration program and park management and research. During a four-day exploration trip in October, a survey team consisting of Dan Austin, Derek Bristol, Kelly Mathis, Rene Ohms, and Chris Pelczarski discovered the first subterranean lake, likely the intersection of the cave with the Madison aquifer. The lake was named Hourglass Lake after the Hourglass Sea on Mars, the first named feature on another planet. The discovery of the Hourglass Lake also nearly coincided with the discovery of liquid water on the red planet. The lake surface, while small at about 10 feet by 15 feet, provides an excellent vantage point from which to see a large, flooded chamber below, estimated to contain approximately 58,000 gallons of water.

Another camp trip in November, 2015 discovered a second lake about 100 feet away from Hourglass Lake. This second water body was named Piso Mojado, or "Wet Floor" in Spanish. Piso Mojado is likely the same water as Hourglass Lake, separated by breakdown-filled passage. The two lakes are the deepest recorded point in the cave at -724 feet.

Since their discovery, some initial monitoring at the lakes shows wa-

Chris Pelczarski at Jewel Cave's Hourglass Lake. NPS photo by Dan Austin

ter levels have risen about one foot from October 2015 to April 2016. Cavers and Park staff also collected water samples from Hourglass Lake in February, 2016 to be used for a USGS / NPS study to determine potential groundwater sources and to model groundwater flow at both Wind Cave and Jewel Cave. A multivariate analysis will be used in this study to look for the presence and concentrations of Arsenic, Silica, Magnesium, Sodium, Alkalinity, Sulfate, Calcium, Chloride, and isotopes of Strontium (87Sr/86Sr) and Uranium (234U/238U). It is anticipated that this analysis will provide important information that will be used in constructing a groundwater model of the area to evaluate the effects of existing and proposed groundwater withdrawals on water levels within both park units. In addition to the USGS study, lake samples have been sent to Dr. Hazel Barton to provide an initial microbial cell count. This study would potentially determine the microbial similarity between the lakes at both Wind Cave and Jewel Cave, and pave the way for future in-depth microbial studies deep within Jewel Cave.

The discovery of the lakes has also been productive in aiding exploration trips to the furthest reaches of the Splinter section. With an almost inexhaustible supply of water, survey teams now have access to a water source more than three hours' travel time from West Camp. In March, 2016, management staff conducted an overnight work trip from West Camp to the lakes. A peristaltic pump was brought into the cave on this trip and attached to 50 feet of sterile tubing and a check-valve leading to Hourglass Lake. Water can now be easily retrieved from the lake without the concern for accidental contamination of the water by frequent close-proximity visits by cavers. In addition to the water pump, management staff marked the main travel route with flagging tape over a mile and a half from the lakes back to the Southwest Splinter. The entire travel route from the entrance to the lakes is now flagged with colored tapes.

A close-call incident in January, 2016 luckily resulted in only minor injuries for volunteer caver Ian McMillan. Ian was surveying beyond the lakes in the Splinter section, and traversing a shallow pit when a portion of the wall he was using as a handhold broke free, causing him to fall about 9 feet into the pit where he landed amidst jagged breakdown. Ian suffered mostly scrapes and bruises, but the most serious wound was a deep laceration to his left calf muscle that had the potential to become infected. Because the injury happened in an extremely remote location, it took

the team 24 hours from the time of injury to exit the cave, including spending about 12 hours resting at West Camp on the way out. The incident was an eye-opener to many cavers who spend time surveying in Jewel, and prompted a re-evaluation of first-aid supplies carried by all team members on cave trips.

The discovery of Piso Mojado Lake in November 2015 was the culmination of the most productive year in history at Jewel Cave for exploration. Survey teams added over 7 miles to the length of the cave in 2015 on 16 exploration trips (an average of 2,359 feet per trip). 25 cavers in total volunteered more than 2,248 hours on exploration and management trips in 2015. 2016 has gotten off to a rockier start, with only 1.6 miles added so far, but there is every indication that this will improve as the summer season arrives.

NPS archaeologist Allison Young and CRF archaeologist Richard Young (no relation) document a cave site. Photo by Mark Jones.

Ozark National Scenic Riverways

Submitted by Scott House

Heading into the winter bat hibernation season we expected no good news and we did not get much. During the winter of 2014-15 we had few occurrences of visible WNS. This past winter, we had almost no caves that did not have bats with visible fungus on them. Populations of northern long-eared bats were down or non-existent and pipistrelle (tri-colored) bat populations were lower in several caves. The only reasonable good news was that so far Indiana and gray bat populations were stable. Three priority-one gray bat caves are within the authorized boundaries.

Folks out west who are now facing staff and caver decon issues are encouraged to contact us for information on how we deal with the issue.

Since the beginning of the 2016 fiscal year there have been over 110 monitoring visits to caves within the authorized boundaries. These trips resulted in over 360 faunal records being added to the state cave database; the species ranged from the usual (wood rats and salamanders) to the less common (small-footed bat) to the rare (pygmy rattlesnake). Most of the monitoring is done by Cave Research Foundation personnel (volunteers and researchers) plus NPS staff and other agency staff. While much of the monitoring was bat-based, archaeological monitoring was done on a number of cave sites as well.

A biological survey of several extensive stream caves is continuing despite very high water levels throughout the winter. A major flood at Christmas caused vast amounts of damage throughout the park and slowed cave work, having washed out a number of roads needed for access.

CRF welder Joe Williams puts the finishing touches on the Wallace Cave gate. Photo by Scott House.

Healthy Indiana bats in an Ozark cave. Photo by Jim Ruedin.

Surveying of park caves continued at a low level through the winter. Survey trips to two stream caves netted more than a thousand feet of new survey.

One cave was gated to prevent visitation and to stabilize bat populations. Two other gates were repaired after vandalism events.

Timpanogos Cave National Monument

Submitted by Nathaniel Gilbert

Over this past winter, Timpanogos Cave National Monument put some of its competitively earned NPS project budget toward a technology that would allow more visitors to see the caves, without actually having to hike the steep mile and a half mountain trail. Led by Physical Science Tech, Blase LaSala, 378 scans were produced throughout the caves with 3D laser scanning equipment. These high-quality images were stitched together using Point Cloud Software to create a 3-D model of the cave. This data set has given rangers the ability to create a fly-through tour of the entire cave trail visitors would see on a tour. Blase has even incorporated a video game engine to develop a prototype interactive "walk-through" of one of the largest open areas in the cave system. In the future, the monument would like to use this proxy cave-view for some interactive exhibits in the new Visitor Center that will be starting construction in September. Due to this development, Timpanogos Cave National Monument will be shortening its 2016 season, closing after September 5th.

The Natural Resources Conservation Service is planning a rehabilitation project for Tibble Fork Dam, up the canyon from Timpanogos Cave National Monument, to meet current safety standards. The reservoir held by the dam may contain heavy metals in the river sediment, which would have been brought in from several mines located further up the canyon. The Water Resources Division of the National Park Service located in Fort Collins, Colorado, have supplied the Timpanogos Resource Management Division with a river monitoring device to detect river water quality before, during, and after the work on the dam. With this new tool, we will be able to measure pH, specific conductivity, turbidity, dissolved oxygen, and a few other variables of the American Fork River at regular intervals.

The latest addition to the Resource Management Division is Nathaniel Gilbert, the new seasonal Physical Science Technician. Nathaniel has a bachelor's degree in Geology, with an interest in cave and karst landscapes. He has worked at Carlsbad Caverns National Park as a Cave Guide, and started his caving career at Oregon Caves National Monument as a GeoCorps intern. During his time at Timpanogos Cave National Monument, Nathaniel will mainly be performing environmental data collection in the cave and at the surface, responding to resource incidents, and assisting with medical incidents on the steep mountain trail.

The deadline for the Winter 2016 issue of Inside Earth is September 1, 2016.

National Park Service
U.S. Department of the Interior

Cave and Karst Program
Geologic Resources Division
P.O. Box 25287
Denver, CO 80235-02787

Inside Earth is the newsletter for the Cave and Karst Program operated out of the Geologic Resources Division of the Natural Resource Science and Stewardship Program of the Washington Office in Lakewood, Colorado. This newsletter is published twice a year for staff, friends, and partners across America.

Editor
Bonny Armstrong

Article Contributors

Dan Austin	Gretchen Baker	Laura Baumann
Nathaniel Gilbert	Rod Horrocks	Scott House
Stephanie Kangas	Dale Pate	Kayla Sapkota
Eric Weaver		

Photographers

Dan Austin	Gretchen Baker	Derek Bristol
Matt Bumgardner	Rod Horrocks	Scott House
Mark Jones	Stephanie Kangas	Tom Kaye
Johanna Kovarik	Jim Ruedin	Kayla Sapkota

Comments? Write to:
Inside Earth
Geologic Resources Division
P.O. Box 25287
Denver, CO 80235-02787
dale_pate@nps.gov