Park News

Great Basin National Park
National Park Service
U.S. Department of the Interior

The Midden

The Resource Management Newsletter of Great Basin National Park

Lehman Caves: Little Understood but World-Class Cave

by Louise D. Hose, retired NPS geologist

INTRODUCTION
While preparing to develop new interpretive displays at Great Basin National Park, the Park staff came to realize that the most recent, professional geologists' reports on the cave were from the early 1960s…..several years before most geologists had even heard of Plate Tectonics!

The early work was very good and done by USGS geologists with ties to caving, including soon-to-be NSS President George Moore. But, we know so much more now about speleogenesis. In the 1960s and 70s, we referred to Lehman and other eastern Nevada caves of the same ilk (such as Old Mans and Crystal Ball) as "phreatic caves" and their speleogens as "boneyard."
As our community started to understand hypogenic speleogenesis thanks to efforts in the Guadalupe Mountains, Europe, Mexico, and elsewhere, informed cavers visiting these caves recognized that Lehman and the others are surely the products of hypogenic waters, but almost nothing was written and no focused study attempted. That is, until now.

The Park contacted me about a year ago (Spring 2017) and asked if I would be interested in looking more closely at the cave and help them better understand what they were attempting to interpret. The timing was nearly perfect in my life, and I was anxious to find a project to dive into. I cleared some time in the fall and our first trip was in November. From that reconnaissance and later visits, I am beginning to have a better understanding of the speleogenesis of the cave. The following article is excerpted from a paper I prepared for the Park staff on the Geologic Story of Lehman Caves.

WHEN AND HOW DID THE CAVE FORM?
Lehman Caves' geology is remarkably understudied compared to most major caves so we don't have as clear of understanding as we hope to develop in the future. One thing is obvious, however, the cave is very old and unrelated to the current surface conditions. How old? Probably between 2.2 and 10 million years old. It also formed very differently than the manner described in most beginning geology textbooks.

Before going any further with this discussion, there are several points worth remembering as we contemplate how this cave formed:

1. The entire cave may not have formed in the same way or at the same time.

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NPS Photo

Ubiquitous gypsum crust in the Gypsum Annex provides evidence of active, sulfidic speleogenesis in the cave's past.

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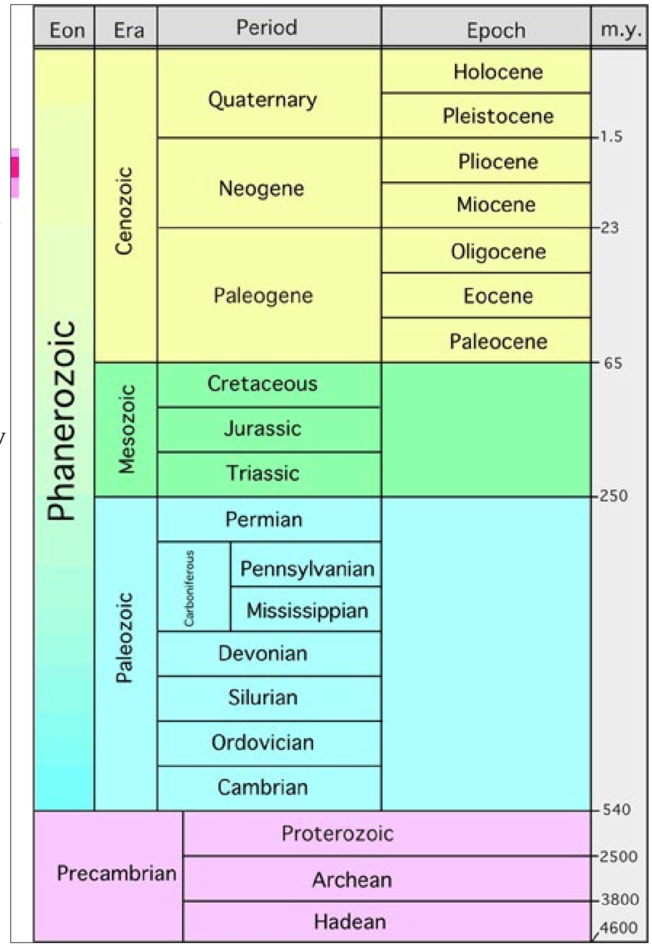
2. There may have been several periods of cave development, each using different processes. At this time, we see four, clearly different periods of change in the cave but the story is likely more complicated. Much more research will be needed to fully understand this special cave

3. The cave void MUST have formed *before* the beautiful decorations. And, the cave development (called "speleogenesis") might have been (and probably was) millions of years before most of the decorations (called "speleothems") started filling in the void.

STAGE 1 – SULFIDE-RICH, HYPOGENIC SPELEOGENESIS
Off the beaten path and in the northwest part of the cave, the Gypsum Annex reveals important clues about the earliest history of the cave. This area is mostly devoid of the beautiful calcite speleothems (e.g., stalactites, stalagmites, columns, and shields) that populate the rest of the cave. Here a geologist can more clearly see evidence of how the cave (or, at least this passage) formed. In the Gypsum Annex, we see compelling evidence of sulfide-rich, hypogenic speleogenesis.

The Gypsum Annex, and likely all of the cave, was formed by warm, sulfur-rich waters rising from deeper in the earth while the Pole Canyon marble was still buried deep below the surface (but after the marble had cooled following the last metamorphic event). Waters rising from deep in the earth are called "hypogenic" and were likely also high in carbon dioxide content (like soda water). We don't yet know where the water or the sulfur came from, but sulfur-rich warm/hot springs are still common in the Great Basin so it is not hard to envision such water flowing through the cracks in the Pole Canyon marble many years ago. Now, the thing to know about sulfur-rich water and limestone is that the water doesn't easily dissolve the limestone until it is very close to the top of the water table and the sulfur can mix with free oxygen (O_2). When this happens, sulfuric acid (i.e., battery acid) forms and it is extremely corrosive. So, water-filled tubes began to form where sulfur-rich water from below mixed with fresh water seeping in and carrying free oxygen from the surface. Since the waters were most aggressive near the top of the tubes, we look to the ceilings of the cave for evidence….bubble trails (smooth grooves in overhanging walls and ceilings), cupolas (smooth-walled ceiling domes), and ceiling drains (round tubes in ceilings and high on walls that look like drains but go up). These features are abundant throughout the cave and tell the trained eye that the cave formed from hypogenic waters. Carbon dioxide-rich waters also become much more aggressive as they reach the top of the water table and form the same sort of features, but the CO_2-charged waters are far less potent than the sulfur-rich waters.



Geologic time scale. The first stage of speleogenesis occurred between 17 Ma (million years) and 2.2 Ma ago. The most probable time, based on the geologic history of the area, was around 10-8 Ma ago.

The Gypsum Annex is a special place because the walls and ceilings are mostly lined with gypsum ($CaSO_4 \cdot 2H_2O$) crusts which formed as the sulfur-rich, hypogenic waters receded a bit and the passage filled with sulfur-rich air just above the water table. Once the cave sat in this position, the cave passage continued to enlarge through a complex but fascinating process.

Sulfide-rich waters continuing to rise from a deep source were warmer than the cave's wall rocks. As the water rose, two relevant changes took place:

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Lehman Caves Geology (continued)

1.) The reduced overlying rock and water pressure allowed hydrogen sulfide (H_2S) or sulfur dioxide (SO_2) gas bubbles to form and travel along the ceiling of the underwater passage, ultimately being released into the air-filled passage at the top of the water table. If the water was also rich with carbon dioxide, which is usually the case, CO_2 bubbles also travelled along the ceiling.

2.) As the sulfur-rich gases approached the air-filled passage, free oxygen became available which oxidized the sulfur gases. A potent acid, sulfuric acid, formed and attacked the marble passage walls. The most common reaction is:

$$CaCO_3 + H^+ SO_4^{2-} + 2H_2O \dashrightarrow CaSO_4 {}^* 2H_2O + HCO_3^-$$

Two products come from this reaction: gypsum (calcium sulfate) and a bicarbonate ion. In air-filled passages, the ascending thermal waters heated the air, including the water vapor/humidity in the passage, to a temperature higher than the cave walls. This inequity caused condensation on the marble/limestone walls and ceilings as happens in a steam room but this condensation was sulfide-rich. The surface of those walls and ceilings were converted to gypsum.

The above chemical reaction is exothermic and releases significant energy. "Chemoautotrophic" microbes bacteria that do not require sunlight nor photosynthesis but make their living on the heat released by chemical reactions are active and abundant facilitators of the reaction. Thus, the conversion of the exposed marble/limestone to gypsum does not result in a solid, dense mass of gypsum but instead commonly forms a paste-like coating of micro-crystalline gypsum, sulfuric acid, and abundant biomass. When the gypsum paste eventually dried up and the bacteria living inside died, the walls were left covered with gypsum crust. We still see the crust in the Gypsum Annex but it may have covered the walls of the entire cave as the Snake Range rose and the water table dropped.

Then, why is the gypsum crust missing in the tour-portions of the cave? Gypsum, the ubiquitous product of sulfidic speleogenesis, is extremely soluble in water and the rest of the cave became very wet as abundant surface-derived water entered the cave after the enlargement phase passed. The flowing and dripping water not only deposited calcite speleothems but also likely dissolved and removed any earlier formed gypsum. The northwest part of the cave lacks much calcite, suggesting an impermeable cover between the Gypsum Annex and the surface protected the gypsum from invading surface waters.

Editor's Note: Stay tuned to future issues of The Midden to learn about the next steps in the cave process.

Photo by Paul Dye

The gypsum crust in the Gypsum Annex takes interesting forms and shows various thicknesses.

Photo by Paul Dye

A floor vent rimmed by gypsum crust is, perhaps, the most compelling evidence of sulfidic, hypogenesis of the Gypsum Annex of Lehman Caves.

2018 Beetle BioBlitz Results

by Gretchen Baker, Ecologist

NPS Photo

BioBlitz participants consult with Nevada state entomologist Jeff Knight about the beetles they found.

Over 40 participants gathered over three days for Great Basin National Park's tenth annual BioBlitz. Nevada State Entomologist Jeff Knight led the effort, focused on beetles.

Attendees included the Nevada Department of Agriculture, Nevada Division of Forestry, Nevada Natural Heritage Program, Bristlecone Audubon Society, US Forest Service Forest Health Protection Program, Natural History Museum of Los Angeles, and Utah Master Naturalist Program from Utah State University, as well as citizen scientists from Nevada, Utah, and California.

The BioBlitz opened with a workshop about beetle biodiversity and how to collect beetles, given by Jeff Knight. This was followed by a demonstration in the field of how to collect using various methods such as sweep nets and hand collecting with forceps during the day and using light traps at night as well as Berlese funnels. Participants then had options of where they wanted to go to search for beetles for each day and night. Habitats from the Great Basin Visitor Center at 5,300 feet to the top of Wheeler Peak at 13,063 feet were visited, including streams, wetlands, woodlands, sagebrush, and grassy areas.

On the third day, US Forest Service forest health entomologist Danielle Malesky gave a talk at the 10,000-foot high Wheeler Peak Campground amphitheater about mountain pine beetles. She described their life history and explained how they use trees and how the USFS and the park are partnering to help high priority trees, such as those found around the campground. She demonstrated how to use the pheromone Verbenone to send a chemical signal that the campground trees were already full of beetles so that other beetles would go elsewhere. She also emphasized how important it is to buy local firewood, as transporting firewood across county or state lines can bring new pests and insects to an area that can decimate those trees.

The BioBlitz concluded with a catered lunch by Salt and Sucre sponsored by the Great Basin National Park Foundation and Western National Parks Association (WNPA), a talk about the preliminary results, and raffle prizes sponsored by WNPA. Over 500 specimens were collected during the BioBlitz. Preliminary identifications estimated 65 species added to the park list, including numerous flower and leaf beetles. Nevada State Entomologist Jeff Knight took the beetle specimens back to his lab and will continue identifying them over the next months.

Next year's BioBlitz will focus on bats in August. Email GRBA_BioBlitz@nps.gov to be added to the mailing list.

Great Basin National Park thanks all who participated in the Beetle BioBlitz, supporting biodiversity in the national parks.

NPS Photo

BioBlitz Participants use a microscope to see their finds better. A workshop at the beginning of the BioBlitz informed participants of what to look for.

First Season of Great Basin Wildrye Implementation

by Gretchen Baker, Ecologist

The *Forgotten Grasslands: Restoration of Basin Wildrye Ecosystems* project was surveyed for archeological clearance during the 2017 fiscal year. Beginning in spring of 2018, we started implementing the restoration. Areas of cheatgrass and crested wheat grass were sprayed, pre-treatment monitoring plots were installed, and restoration by thinning began.

A five-person Nevada Conservation Corp (NCC) crew, sponsored by the Great Basin Institute (GBI), spent twelve weeks at the park. For five of the weeks, they cut down pinyon pine (*Pinus monophylla*) and Utah juniper (*Juniperus osteosperma*) near the park entrance. They left bigger trees, but cut the eight inch and smaller dbh (diameter at breast height) trees to allow the underlying sagebrush and grasses to have more space. They worked on approximately 15 acres. As you can see in the before and after photos, this thinning helped open up the landscape. It also helps provide more of a fire break.

Additional crews will be coming in the fall and future years to complete the project. Seeding native species and planting Basin wildrye are also a component in this project.

NPS Photo

NPS Photo

Before (top) and after (bottom) photos of a thinning area along the Wheeler Peak Scenic Drive to restore sagebrush and grasslands. The removal of pinyon pine and juniper trees also helps provide a better fire break. You may notice the bright blue skies in the photo taken in June; for the after photo in August, a smoky haze filled the sky many days.

Upcoming Events:

September 6-8 Great Basin National Park Astronomy Festival Enjoy some of the darkest night skies in the country with talks, activities, and multiple telescopes. Find more info at: https://www.nps.gov/grba/planyourvisit/astronomy-festival.htm

October 5-7 Western Regional Meeting of the NSS at Great Basin National Park. Learn about park and nearby caves, fauna, and more. More info at https://wrnss2018.brownpapertickets.com/

Walk on the Wilder Side

By Peggy Horton, Park Volunteer

Looking for your next new adventure!? You will find it at Great Basin National Park. Specifically at Lehman Caves. Just imagine a cave adventure in a place that is dark, cool and quiet, very mysterious, and sparklingly beautiful! It is an adventure that is packed with discoveries. An adventure that you can share with friends and family.

I came to Great Basin National Park from the "Live Free or Die" state of New Hampshire. Eleanor Roosevelt had inspired me with her quote "Do the Thing You Think You Cannot Do." I accepted a three-month volunteer position where I supported the Lehman Cave rangers who offer guided tours of fabulous cave rooms filled with geological wonders. Each room of the tour offers new sights and unique formations. As you walk the pathways, you travel back in time millions of years to the creation of the cave and its decorations. You will also hear stories of the history of the cave, stories of early visitors and their actions. And you will leave the blue skies and sunny weather above while you explore deep into the dark and quiet, an environment that is challenging to your senses. Each time I visit the caves I find something new, something more.

If you are taking the 90-minute tour, when you reach the Sunken Garden, look beyond the railing. You will see another rough pathway in the darkness, an opening, something else "out there." Something beyond the guided tour. Something wilder. Luckily I was able to find out. I was very fortunate to have been invited to join an enthusiastic group of volunteers from all over the country; we were going to "Lint Camp" together. Lint Camp is a special opportunity to work with the Lehman Cave resource management staff to help restore the cave to its natural state. Some people "dust" debris from the formations, others scrape up dirt from old pathways, and still others treat algae that grows near the lights. But the prize at the end of the work day is a guided "off trail" tour of the Talus Room and the West Room! This experience is wilder, darker and more challenging, but it is those things exactly that bring the thrill.

NPS Photo by G. Baker

Lint cleaning in the Giant's Ear area.

The first thing you notice is the darkness, even though you have a headlamp and others are with you, the darkness invades corners, the ceiling and cracks. The pathway is gone and you have to scramble and climb over broken rock like

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Walk on the Wilder Side (continued)

mountain goats. You have the sense of entering into the unknown. The walls beside you are tall and feel limitless in the dark. Soon the guide explains that a 15-foot climb over large rocks is ahead.

As you pull and scramble, make sure to have a solid grip and steady footing. The helmet comes in very handy as low hanging rock abruptly appears. At the top of the climb you can hike up further to magnificent flowstone, covered in initials and writing from years past. Everyone creates their own story from the writings, a camaraderie of past and present.

You pass by the small opening of Gypsum Annex, but that's an adventure for another day. As the group soldiers on, a large room,

NPS Photo

Lint camp participants entering an off-trail area of the cave.

as long as football field, 80 feet tall, opens before you. The walls have a glow of rainbow color. And the formations begin to become more elaborate than what you have seen so far on this trip. Soda straw forests hang from the ceiling, each with a drop that looks like starlight in the headlamp light. Concrete and real, yet magical. So much to see and wonder at, that in what seems like no time, you are returning to the developed cave pathway. It feels like a coming home. Time to share the adventure with those above.

The Park Service is working on developing this experience into a more advanced caving trip. It is another way to get people excited about the beauty and wonder of the caves and hopefully inspire them to protect them as well.

To be added to the Lint and Restoration Camp emailing list, send an email to GRBA_Lint_Camp@nps.gov.

Recent Publications about Great Basin National Park

Devitt, D., Bird, B., Lyles, B., Fenstermaker, L., Jasoni, R., Strachan, S., ... & Saito, L. 2018. Assessing near surface hydrologic processes and plant response over a 1600 m mountain valley gradient in the Great Basin, NV, USA. Water, 10(4): 420. Link

Hamilton, B. T. 2018. Small mammal diversity, rattlesnake demographics, and resource utilization in the Great Basin: Implications for management and stable isotope proxies. Ph.D. Dissertation. Brigham Young University. Provo, Utah. Link

Hershler, R., Liu, H. P., Forsythe, C., Hovingh, P., & Wheeler, K. 2017. Partial revision of the Pyrgulopsis kolobensis complex (Caenogastropoda: Hydrobiidae), with resurrection of *P. pinetorum* and description of three new species from the Virgin River drainage, Utah. Journal of Molluscan Studies, 83(2): 161-171. Link

Leavitt, S. D., Newberry, C. C., Hollinger, J., Wright, B., & St. Clair, L. L. 2018. An integrative perspective into diversity in *Acarospora* (Acarosporaceae, Ascomycota), including a new species from the Great Basin, USA. The Bryologist, 121(3): 275-285. Link

Musegades, L., Niebuhr, C., Graham, M., Poore, A., Freed, R., Kenney, J., & Genet, R. 2018. An astrometric observation of binary star system WDS 15559-0210 at the Great Basin Observatory. Journal of Double Star Observations, 14: 197-200. Link

Santucci, V. L. 2017. Preserving fossils in the national parks: A history. Earth Sciences History, 36(2): 245-285. Link

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The Midden is the Resource Management newsletter for Great Basin National Park.

A spring/summer and fall/winter issue are printed each year. *The Midden* is also available on the Park's website at www.nps.gov/grba.

We welcome submissions of articles or drawings relating to natural and cultural resource management and research in the park. They can be sent to:
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What's a midden?

A midden is a fancy name for a pile of trash, often left by pack rats. Pack rats leave middens near their nests, which may be continuously occupied for hundreds, or even thousands, of years. Each layer of trash contains twigs, seeds, animal bones and other material, which is cemented together by urine. Over time, the midden becomes a treasure trove of information for plant ecologists, climate change scientists and others who want to learn about past climatic conditions and vegetation patterns dating back as far as 25,000 years. Great Basin National Park contains numerous middens.

Great Basin National Park

Lehman Caves' Shields

by Louise Hose, retired NPS geologist

Lehman Caves is an extraordinary cave with a complex history. One of its more obvious distinctions is hundreds of cave shields. An unusual cave decoration, Lehman may contain more than any other cave in the world. But, why?

The simplest answer is that the bedrock is highly fractured and shields form from water oozing out of cracks. Cave shields form from fractured rocks. In addition, Lehman is an old cave (one stalagmite has been dated as 2.2 million year old) and there's been plenty of time for lots of calcite speleothems to grow, including shields. As to how they form, the origin of shields is still something of a puzzle. What we do know is:

a. Actively growing shields are two, parallel plates of calcite separated by a crack thin enough to only allow capillary seepage.

b. The two plates grow outward into air-filled passages and develop concentric growth bands around their water sources, which are clearly displayed by many of the half-shields along the tour route of the cave. (Note: There is no evidence that the growth bands in shields represent annual growth as in tree rings.)

c. Active growth was along the outer edge of the plates, where CO_2 is able to escape into the cave atmosphere and the water became supersaturated. (Stalactites, stalagmites, and other common cave decorations form from the same process when dripping or flowing water loses carbon dioxide and becomes super-saturated.)

NPS Photo

The Parachute shield (left) and others in the Grand Palace are examples of shields with abundant calcite draperies formed by supersaturated water flowing out of the medial crack between the shield's two plates.

d. During periods of increased water flow that leads to pressure that overwhelms the capillary seepage, gravitational water deposits stalactites and draperies around the shield edges (e.g., The Parachute).

e. In many caves, including Lehman, there appears that the internal gap between plates widens toward the shield interior. Thus, undersaturated water seeping out from the original fracture may dissolve calcite from the inside of the already established plates and then re-deposit the calcite when the water reaches the edges of the plates and CO_2 escapes. This eating away from the inside activity may also weaken one plate's attachments to the site and contribute to separation and apparent collapse of the bottom plate of many shields seen within Lehman.

NPS Photo by G. Baker

Upper plate of a shield near the Exit Tunnel. The lower plate has fallen away exposing the corrugated inside of the upper plate, which is suspected to have been caused by stagnant water or "strand" lines deposited when the shield was drying out and the lower plate was intact.