



2009-2010
ANNUAL REPORT

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Cover Photo

Students and invited lecturers of the 18th International Karstological School trek along the floor of Rakov Skocjan’s giant sinkholes and caves in Slovenia. The school is a function of Slovenia’s Karst Research Institute. NCKRI is proud to have signed cooperative memoranda with them and two other prominent karst research institutes this year (see page 20). Photo by George Veni.

Back Cover Photo

NCKRI scholar Aaron Curtis rappels into the entrance of Warren Cave, a fumarolic ice cave on Mount Erebus, Antarctica, formed by melting of the ice on the slopes of the mountain by underlying warm volcanic gasses. See pages 15-16 of *Student Activities* for more information. Photo by Nial Peters, courtesy of Aaron Curtis.



Vision Statement

The National Cave and Karst Research Institute (NCKRI) will be the world’s premier cave and karst research organization, facilitating and conducting programs in research, education, data management, and stewardship in all fields of speleology through its own efforts and by establishing an international consortium of partners whose individual efforts will be supported to promote cooperation, synergy, flexibility, and creativity.

Organization and Mission

NCKRI was created by the U.S. Congress in 1998 in partnership with the State of New Mexico and the City of Carlsbad. Initially an institute within the National Park Service, NCKRI is now a non-profit 501(c)(3) corporation that retains its federal, state, and city partnerships. Federal and state funding for NCKRI is administered by the New Mexico Institute of Mining and Technology (aka New Mexico Tech or NMT). Funds not produced by agreements through NMT are accepted directly by NCKRI.

NCKRI’s enabling legislation, the National Cave and Karst Research Institute Act of 1998, 16 U.S.C. §4310, identifies NCKRI’s mission as to:

- 1) further the science of speleology;
- 2) centralize and standardize speleological information;
- 3) foster interdisciplinary cooperation in cave and karst research programs;
- 4) promote public education;
- 5) promote national and international cooperation in protecting the environment for the benefit of cave and karst landforms; and
- 6) promote and develop environmentally sound and sustainable resource management practices.

NCKRI Annual Report Series

NCKRI produces a report of its activities each year. The reporting period covers NCKRI’s fiscal year, from 1 July to 30 June of the following year. To minimize costs and environmental impact, a relatively small number are printed . Digital copies of this and previous reports are available for free at www.nckri.org.



EXECUTIVE DIRECTOR'S REPORT

When I accepted this job and joined NCKRI in February 2007, I knew I would be trading my caving helmet for a construction hardhat. The trade was literal and figurative. I wear it each time I visit our headquarters and review its ongoing growth. But I figuratively wear that hardhat as I build the administrative and staffing foundations for the institute.

While the national economy has been highly stressed during the past year, and NCKRI tightened its belt like many other organizations, we still had the strength to grow with the support of our partners. As many businesses closed down, we continued building our headquarters, in large part due to the efforts of the City of Carlsbad. As many workers were laid off around the U.S., we will soon be hiring another major position, an Advancement Director, to help us raise funds and diversify our sources of income.

Our investment in geophysical equipment this year (see page 4) increases the services we can offer. Our Educational Program's Strategic Plan is nearly complete, so NCKRI workshops, seminars, and other learning activities will soon be available. Interest remains high and positive in our publications; we are considering options for future editions in our report series.

I would love NCKRI to grow faster, but in many ways this slower, steady expansion is better. Often when we start a project or activity, we need to research and write protocols to make sure our efforts are consistently best spent, of the highest quality, fiscally and environmentally sound, and considerate of our partners. These procedures are not discussed elsewhere in this report; we don't expect our friends to share our excitement when we wave around a new policy! Creating them is slow and time-consuming due to the amount of thought and review we apply to do them correctly. Yet they are part of the vital administrative foundation for NCKRI. Our steps forward may currently be slow, but they are firm, with few missteps or backtracking.

I expect that within the coming year we will leave our temporary offices and move into our new headquarters. I hope the building will be complete, but realistically expect that some additional construction will be needed. The timing will roughly be at a convergence of several important milestones that will allow us to start taking faster and broader steps:

- The building will raise our public profile. We'll host more events, rent meeting space and open our bookstore.
- Our Education Program's Strategic Plan will be complete, allowing us to work more effectively in cave and karst education locally and globally.
- Our website is overdue for an overhaul. A major upgrade is in the works and is critical to raising our national and international profiles.
- Administrative work is declining, staff levels are rising, and specialty equipment is in hand, allowing us more time and resources to conduct our own research and assist others with theirs.
- A carefully designed strategy will be in place to generate revenue from grants, sponsorships, and other generous acts, in addition to the items listed above that will further expand NCKRI's capabilities.

Normally our annual reports close with our strategic plan for the next several years. We have omitted it this time. There haven't been many changes since last year, and the upcoming year will require us to thoroughly revisit that plan, make sure it is still realistic and that it takes advantage of new opportunities we currently can't see. As always, your support and friendship is greatly appreciated.

George Veni, Ph.D.

NCKRI HEADQUARTERS CONSTRUCTION

Phase 1: Framework

Construction of NCKRI Headquarters began in November 2008. An unpredicted increase in the cost of materials resulted in the cost of the building exceeding the available funds. Funds for construction were provided by the National Park Service, the State of New Mexico, and the City of Carlsbad, which will own the building and lease it to NCKRI. Construction began with the understanding that the headquarters would be completed in phases as additional funds became available.

Phase 1 laid the foundation and framework for the building. All of the exterior was scheduled for completion, as were some interior spaces: lobby, exhibit hall, bookstore, and restrooms. This phase was finished in December 2009, as the City of Carlsbad found funds for Phase 2.



Above: Artificial bat roost in a modified eave; NCKRI Headquarters is the world's first building with a bat roost as part of the design.

Top right: Classroom, partially finished.

Middle right: Exterior, facing canal.

Bottom right: Exhibit hall, complete except for the floor finish.

Phase 2: Classrooms

Construction of NCKRI's two classrooms, which can be combined into a single large room, began at the end of 2009 and was completed in May 2010. The combined room has an estimated seating capacity of about 160. As work on this phase was completed, the City of Carlsbad was again able to fund additional construction.





Phase 3: Offices

Work on the second floor started in late May 2010 and is scheduled for completion in September 2010. This phase will construct all offices plus the conference room, work room, and break room. If additional funds are not available when this phase is complete, all public portions of the building will be finished and the headquarters will be occupied, with the remaining areas completed later.

Phase 4: Completion

Completion of NCKRI Headquarters will require funds for the library, laboratory, garage and associated storage, and landscaping. As NCKRI acquires additional staff and will be offering more services in the near future, we hope those funds will be developed soon.

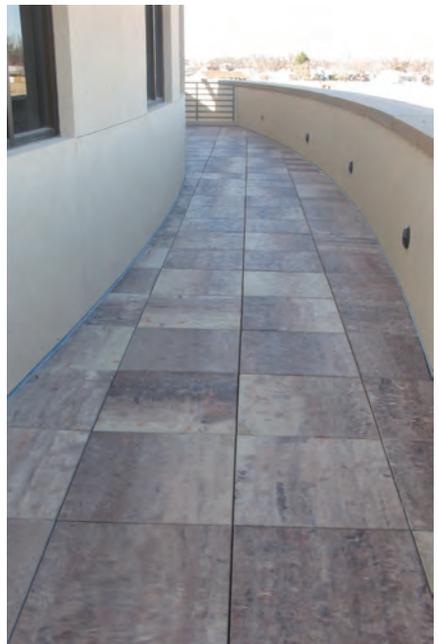


Top left: Framing of southern offices; the open door in the floor gives access to the top of the artificial bat roost to install probes, cameras, and microphones when the building is complete.

Middle left: Insulation, walls, and duct-work installation in the conference room.

Bottom left: Insulation and wall installation of western offices.

Below: Library balcony. Rain drains between the tiles, is captured below them, and then funneled into the landscape.



NCKRI RESEARCH

Geophysical Investigations

In fiscal year 2009-2010, the National Cave and Karst Research Institute began purchasing major research equipment, and NCKRI staff began field trials to develop expertise in their use. Our most notable acquisitions include an Advanced Geosciences, Inc. (AGI) SuperSting R8/IP electrical resistivity (ER) meter and a Topcon GR3 survey-grade Global Positioning System (GPS). In February 2010, Dianne Gillespie and Drs. Lewis Land and George Veni attended four days of training in the use of the SuperSting equipment and Earthimager software at AGI's offices in Austin, Texas. In April 2010, NCKRI staff attended a 2-day training session in Albuquerque, New Mexico on the Topcon GPS equipment.

The basic operating principal for ER surveys involves generating a direct current, or an alternating current of very low frequency, between two metal electrodes set in the ground, while the ground voltage is measured between two other implanted electrodes. Given the current flow and voltage drop between two electrodes, differences in subsurface electrical resistance can be measured and mapped. Resistivity profiles illustrate vertical and lateral variations in subsurface resistivity (see example below). The presence of water or water-saturated soil or bedrock will strongly affect the results of a resistivity survey. Air-filled caves and other void spaces above the water table are easy to detect using the ER method, since air has near-infinite



Photo by George Veni

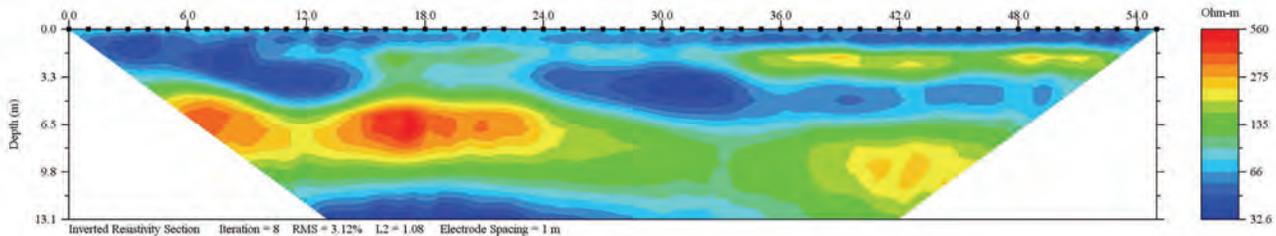
Dr. Lewis Land conducting field trials with the SuperSting resistivity meter.

resistivity, in contrast with the more conductive surrounding bedrock.

The SuperSting equipment package includes the resistivity meter itself, which provides the signal source; a switchbox, which is used to switch on and off the various electrodes during an ER survey; several hundred meters of cable with electrode take-outs; and stainless steel stakes, which serve as the electrodes. Two 12 volt lead-acid batteries provide the power source. A laptop computer is used to upload command files to the resistivity meter and download data files for subsequent processing. Depth of investigation is directly related to length of the array of electrodes – the longer the array, the greater the penetration

that can be obtained. We have the capability of deploying a maximum of 112 electrodes at 6 m spacing during an ER survey, providing a maximum depth of investigation of ~300 meters.

The Topcon GPS equipment will be used in conjunction with the SuperSting to acquire precise location and elevation data along the resistivity profiles. We have also conducted independent GPS surveys for a contract project with the National Park Service at White Sands National Monument. In the near future we anticipate generating a revenue stream for NCKRI by making the resistivity and GPS equipment available for collaborative research projects with other organizations.



Example of a resistivity profile; alluvium in front of NCKRI's temporary offices (see above photo).

Bureau of Land Management Cave Assistance Agreement

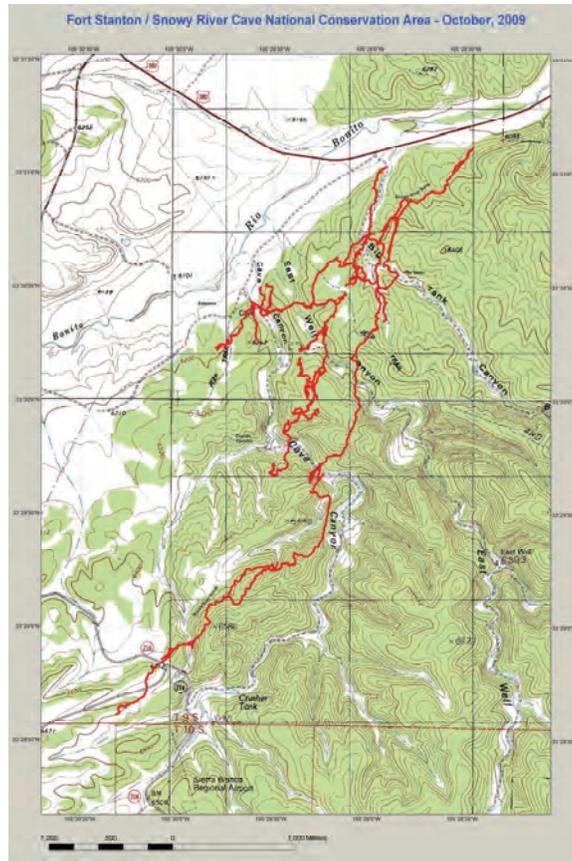
The Fort Stanton Cave Snowy River Passage project continues with the Bureau of Land Management's (BLM) additional funding for two ongoing research topics:

- 1) geomicrobiological work by Dr. Penelope Boston and her colleagues at the University of New Mexico (UNM), Dr. Diana Northup and Michael Spilde; and
- 2) hydrological research by NCKRI's Dr. Lewis Land and UNM's Dr. Victor Polyak.

Fort Stanton Cave

For the past seven years, NCKRI staff have collaborated with the Fort Stanton Cave Study Project in investigations of the geology, microbiology, and hydrology of Snowy River in Fort Stanton Cave, located in the northern Sacramento Mountains of southern New Mexico. The surveyed length of Fort Stanton Cave is currently 23.8 km, making it the third-longest cave in the state, after Carlsbad Cavern and Lechuguilla Cave. The existence of Fort Stanton Cave has been on record since 1855 when the nearby U.S. Army fort, whose name the cave bears, was established. Fort Stanton Cave is now administered by the BLM, which has gated the cave and controls access via a permit system.

In September 2001, a team digging in the Priority Seven breakdown broke through into a new passage. This newly-discovered section of the cave was named Snowy River because of the presence of a snow-white pool deposit that occupies an old stream channel that extends throughout the passage. The Snowy River pool deposit consists of opaque white calcite with a coralloid texture that was de-



Line map of Fort Stanton Cave, New Mexico (courtesy of the Fort Stanton Cave Study Project).

posited on top of red-brown mud that originally made up the bed of the stream. The mapped length of the Snowy River deposit is now more



Photo by John R. Cochran
View of Snowy River looking south.

than 7 km, and continues to extend southward for an unknown distance. It has been suggested that the calcified bed of Snowy River is the longest continuous cave deposit known on earth.

Recognizing the importance of the cave and Snowy River, in 2009 the U.S. Congress established the Fort Stanton-Snowy River Cave National Conservation Area (NCA) to protect, conserve, and enhance the unique historic, cultural, and scientific resources of the Fort Stanton-Snowy River cave system. The NCA includes approximately 25,080 acres that overlie the current known extent of the cave.

The Snowy River passage floods in response to extreme meteorological events such as hurricanes, excessive winter snowfall, or exceptionally high rainfall during the summer monsoon season. The passage was dry during the Fall 2009 expedition and Dr. Land and New Mexico Bureau of Geology and Mineral Resources colleague Talon Newton took the opportunity to deploy

three water level data loggers on the floor of the passage, anticipating future flooding events. The northernmost data logger was deployed in

Crystal Spring. This perennial inflow of water enters Snowy River's northernmost explored end and is believed to flow to Government Spring, a surface spring that discharges into the Rio Bonito ~500 m northeast.

During the fall expedition, Dr. Land and Mr. Newton also initiated a study of the paleohydrology of the Snowy River passage. They measured several channel profiles to estimate past flow velocities, and also made observations and measurements of paleo-waterlines. Three distinct waterlines were observed on the banks of the stream channel in the Snowy River passage. The youngest waterline is the upper edge of the Snowy River deposit itself. Two older waterlines are repre-



Photo by Lewis Land

Paleo-waterlines on mud bank in Snowy River passage.

sented by dark bands of manganese dioxide (MnO_2) on the mud banks above the Snowy River deposit. The highest MnO_2 band occurs ~30 cm above the upper edge of the Snowy River waterline, and is assumed to represent the oldest and highest period of water level stability. These waterlines appear to be present throughout the Snowy River passage, and probably represent episodes during which water levels in the channel were relatively stable for long periods of time (years to decades). Based on observations of the water level history in Snowy River recorded by these paleo-waterlines, it appears the stream channel was a perennial stream in the past, depositing silt, sand and gravel transported in from the surface from an unknown source point, presumably far to the south. A decline in stream flow and transition to ephemeral conditions in the passage might coincide with the onset of calcite deposition ~800 years before present.

One week prior to the Spring 2010 expedition, Snowy River flooded in response to melting of unusually heavy winter snow in the northern Sacramento Mountains (200% of average). Data logger records indicate that water levels rose from zero to ~30 cm in less than one

hour. This flood event prevented earlier plans for further survey and core sampling in Snowy River South, but it also presented an opportunity to measure the stream's flow using NCKRI's recently acquired Flow-tracker acoustic doppler velocity flowmeter. The flow was measured as $0.124 \text{ m}^3/\text{s}$, significantly greater than the $0.05 \text{ m}^3/\text{s}$ flowing at that time from Government Spring. These results confirm previous assumptions that Snowy River discharges its flow to other outlets along the Rio Bonito, in addition to Government Spring. Most of these outlets are probably covered by soil and alluvium along the Rio Bonito.

Also during the Spring 2010 expedition, NCKRI personnel conducted resistivity surveys over the projected northern extension of Snowy River. It was originally thought that the northern end of the Snowy River passage ended in a terminal sump (where the passage is filled with water) at Crystal Spring. However, a high resistivity anomaly near the center of one of the profiles clearly indicates that the Snowy River passage continues to the northeast between the surveyed north end of the passage and Government Spring (see the resistivity profile below).

In addition to the resistivity work, NCKRI staff used the new Topcon GPS equipment to survey a grid over previously-defined resistivity anomalies for a microgravity investigation conducted by the Fort Stanton Cave Study Project. Conducting a successful microgravity survey requires very precise elevation information at each gravity station, and would not have been possible without the high-precision measurements made by NCKRI's survey-grade GPS equipment.

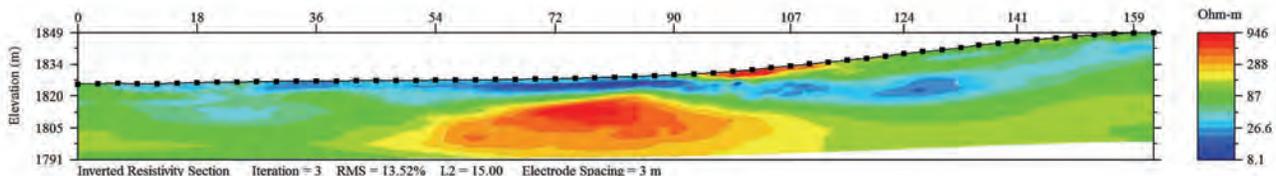


Photo by Dianne Gillespie

Fort Stanton Cave Study Project volunteers using NCKRI's GPS equipment during a resistivity survey.

Ongoing Geomicrobiological Research in Lechuguilla Cave

Lechuguilla Cave, located in Carlsbad Caverns National Park, New Mexico, is the world's fifth longest cave (207 km) and one of the most microbially and mineralogically diverse. NCKRI's Dr. Penelope Boston and Michael Spilde, UNM, conducted a field trip with long-time cave geologist and former NCKRI board member, Harvey DuChene. They followed -up with DuChene on the history and legacy of early research in the cave. Visiting Ghost Town, in the cave's eastern branch, where they found microbially interesting deposits. They also examined extensive breakdown (collapsed rock), that apparently resulted from microbial deterioration of the limestone. Some of its materials were sampled for analysis. Preservation of bedrock fossils was visible in the degraded material, showing the punk rock (rock that is leached of its natural cementing minerals) is a direct weathered product of the bedrock.



Resistivity profile over projected northern extension of Snowy River; the red-orange zone may represent currently unexplored passage.

Naica Cave: Giant Crystals, Tiny Fluids

Dr. Penelope Boston is analyzing samples from the giant crystals of Naica Cave, Chihuahua, Mexico, with colleagues at UNM and several virologists from the University of British Columbia. The microbiology of the crystal fluid inclusions is exceedingly interesting and the researchers have developed a list of organisms that are present within a number of hot and extreme habitats in the Naica Cave system. There is sequenceable DNA material in the crystal fluid inclusions, red wall deposits, and the black imbedded material. These microorganisms are all novel strains and show that their nearest, genetic relatives are geographically distant, but exist in environments that share similarities with Naica Cave, such as active volcanic terrain in Kamchatka, Russia, and certain caves in Australia. Water samples were analyzed and show a very high metal content.

Brine Well Sinkhole Collapses

NCKRI staff have continued making aerial observations of anthropogenic sinkholes in southeastern New Mexico and west Texas. In July 2009, a new sinkhole formed east of Denver City, Texas, about 130 km east of Loco Hills, New Mexico, where two sinkholes associated with



Photo by Michael Spilde

Mexican TV crew member Mario Corsalini in an ice suit by one of the amazing gypsum crystal flowers in the Naica Cave system.

brine wells formed in July and November of 2008. The Denver City sinkhole is also associated with a collapsed brine well. All three well operators were conducting solution-mining operations in the Salado Formation, a thick salt unit in the shallow subsurface, and selling the resulting brine as oil-field drilling fluid.

In the past year, much attention has been focused on a brine well located within the city limits of Carlsbad, New Mexico. This operation, known as the I&W brine well, was shut down in 2008 in the aftermath of the first Loco Hills area brine well collapse. The I&W well is very similar to the Loco Hills area sinkholes to the north in terms of geology,

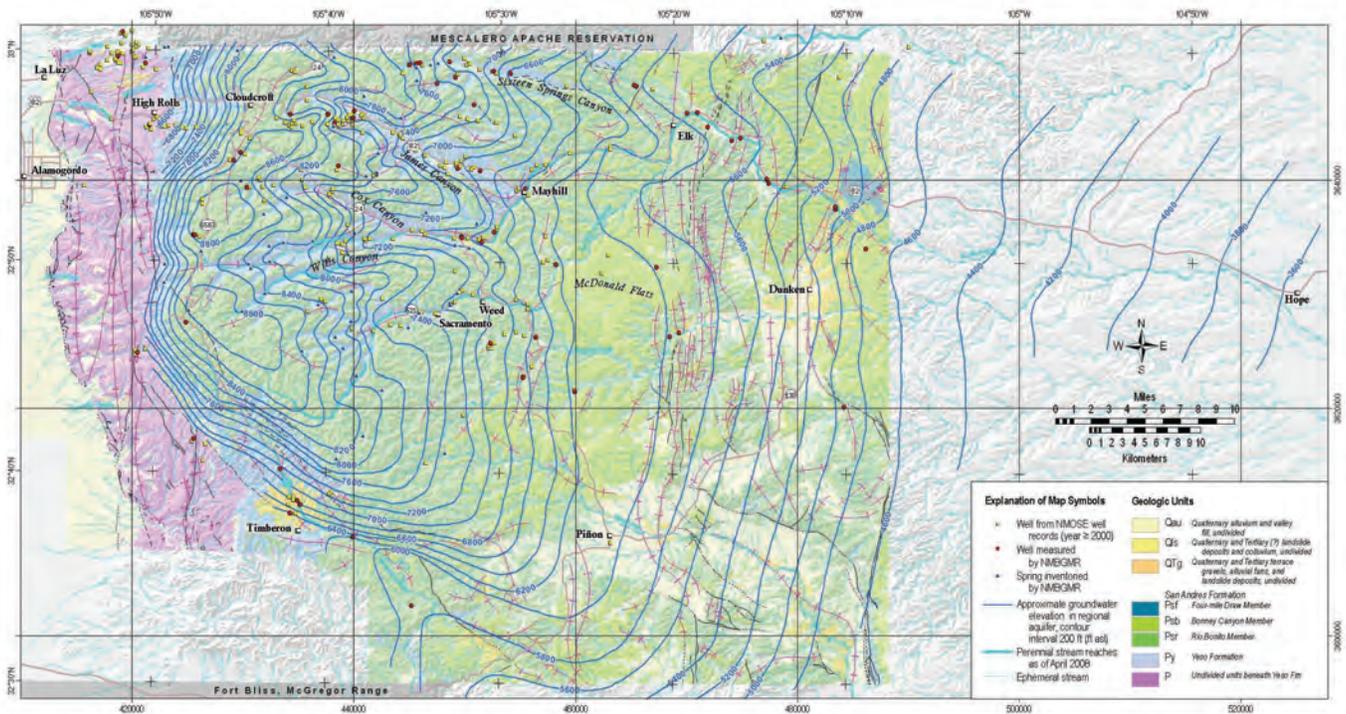
stratigraphy, depth, and volume of brine that had been withdrawn from the Salado Formation. A sinkhole collapse at this location would cause extensive damage and possible loss of life, since the well is located near the intersection of two major highways, the Carlsbad Irrigation District's South Canal, and a mobile home park.

NCKRI's Dr. George Veni serves on the City of Carlsbad's technical advisory committee with several other geology, engineering, and salt mining experts in the area. Their first priority was to establish a series of tiltmeters and other equipment to measure any subsidence that might occur, but also to issue an early-warning alarm if a collapse seems imminent. The alarm connects to the regional emergency network. Their next step is to evaluate the cavity and develop the best remediation strategy. The precise dimensions of the cavity are not known. The committee proposes reentering the well with a sonar device to conduct a sonar survey. The survey will accurately map the size and shape of the cavity, and allow development of a plan to refill and stabilize the cavity in an as safe as possible manner.



Photo courtesy of Larry Pardue

Aerial view of the brine well sinkhole near Denver City, Texas.



Water table map of the southern Sacramento Mountains watershed.

Southern Sacramento Mountains Watershed Investigation

For the past four years, NCKRI's Dr. Lewis Land has participated with colleagues at the New Mexico Bureau of Geology in a watershed-scale investigation of the hydrology of the Southern Sacramento Mountains. This project has been fully funded by the Otero Soil and Water Conservation District. A final report on the results of this work is being prepared and will be published as a Bureau Open File Report in Fall 2010. Sections of the report will also be submitted for publication in peer-reviewed journals.

Dr. Land's contribution to this report has focused on regional groundwater flow conditions, including the above map of the regional water table in the Southern Sacramento Mountains. The aquifer system in the southern Sacramentos is developed primarily within the Permian age Yeso Formation. This heterogeneous unit is composed of siltstone, mudstone, gypsum, and fractured limestone. Water-bearing zones are

distributed throughout the formation, and in most cases it is difficult to determine whether a measured water level corresponds to a perched aquifer or if it is part of the regional water table.

The water table map indicates that most groundwater recharge occurs near the crest of the Sacramentos, where high mountain springs discharge from small, highly-localized perched aquifers. Following the groundwater system downgradient from west to east, the perched aquifers begin to coalesce into a regional flow system that eventually merges with the Yeso-San Andres limestone aquifer in the Roswell Artesian Basin to the east.

Field observations of high-volume spring flow following the 2006 monsoon season, combined with stable isotope measurements, indicate that the Yeso aquifer is a dual or triple porosity karst system. Long-term storage of groundwater is contained in the rock matrix, while short-term, high-volume flow periodically occurs through fractures and solution-enlarged conduits developed in Yeso carbonates.

NASA Infrared Instrument Development

In the second year of this project, instrument development continues on the unique, tunable acousto-optical laser spectrometer to characterize organic components and microbial life—ultimately for extraterrestrial planetary surface use on a future NASA mission. NCKRI's Dr. Penelope Boston and her research team are developing a suite of minerals, that include characterized cave microbial materials, to test the unit.

If microbial life exists on Mars and other planets with harsh surface environments, it will more likely be found in sheltered areas like caves. Dr. Boston and her team are studying caves on Earth, and their microbial communities, as possible surrogates for extraterrestrial environments. Microbes that feed by breaking down minerals in rocks and other geologic materials are a focus of this study. Plans are underway for deploying a field testable acousto-optical laser spectrometer later in the project in a selection of microbially significant caves.

Karst Information Portal

The Karst Information Portal (KIP) is a joint project of NCKRI, University of South Florida (USF), University of New Mexico, and the Union Internationale de Spéléologie (UIS). It is an on-line cave and karst reference source and research tool.

During the past year the KIP team analyzed visitor use over a 30-month period, listened to comments and suggestions from the user community, and made a number of changes. The most visible is the KIP's new design.

Many behind-the-scenes programming changes have improved KIP's efficiency and effectiveness. The new CWIS interface makes it possible for KIP to feed into the National Science Digital Library, a long-standing National Science Foundation-funded project. Another development is the advanced search tool, which supports all of the fields and can limit retrievals by audience, language, format, digital accessibility, etc. Registered users now have a "Recent Searches" list that allows them to quickly repeat up to five recent searches. They can also save searches and have the results e-mailed to them as new materials are added when they fit saved search criteria.

Other improvements include the ability to browse resources, access accessibility options for people with disabilities or who want larger fonts, and improvements in the tagging and quality of data.

The over 5,000 documents currently stored in the library are searchable by over 30,000 keywords. The above table summarizes the changes in information and resources available on KIP since 2009.

KIP is designed for documents to be fully text-searchable, rather than depending on keywords assigned to each document, and that capability will be added later in 2010. While the entire library collection is not yet fully searchable, many of the individual documents are fully searchable.

KIP's usage continues to expand since its launch in 2007. The graph to the upper right reflects usage through June 2010, and is on a trajectory to double usage from the 2009 levels. Refer-

Metadata Element	Current	Change from 2009
Number of Classifications	161	+15
Number of Controlled Names	7,644	+1,943
Resources Published for Viewing	4,599	+511
Total Number of Resources	5,528	+447
Total Distinct Resource Search Terms	33,521	+3,062

als from Google account for 68 percent of visits. Notable recent additions to KIP's virtual library include:

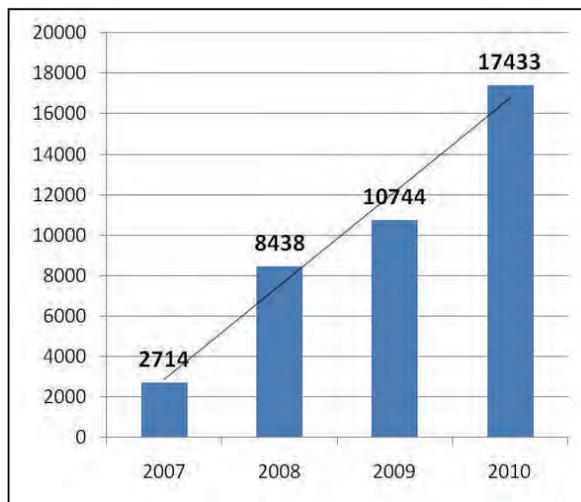
- All issues of the *NSS News* (with a moving five-year embargo on the most recent issues);
- Select issues of *Speleo-Digest*;
- All of the *Proceedings of the National Cave and Karst Management Symposia*; and
- Elements from the library of technical reports of NCKRI's Dr.

George Veni that have been digitized and made accessible.

KIP is developing into a digital archive for existing journals concerning karst environments. It can also support future peer-review, editorial management, and online publication. NCKRI has initiated one such collaboration between the UIS for USF Libraries to publish the *International Journal of Speleology* (IJS). The tentative agreement, being finalized as this annual report goes to press, will make the IJS an on-line open-access journal. USF will support print versions of the journal through 2012.

Agreements with the editors of *Geo²*, *The Texas Caver*, and *Got Karst!* have been reached and digitization and/or classification work for those publications and products is underway. Discussions have also begun with Texas' Edwards Aquifer Authority to host reports generated by their Aquifer Science Research Program and to retrospectively digitize older materials.

Statewide budget reductions in Florida and USF have put pressure on the KIP initiative, but do not endanger



KIP usage 2007 to June 2010.

KIP's existence and long-term survival. While this has slowed the pace of development, current modest but persistent investments are generating the desired outcomes in content, usage, and improved features.

Lava Tube LiDAR Survey with Navajo Tech

NCKRI's Dr. Penelope Boston and Lisa Majkowski, along with Michael Spilde of the University of New Mexico and Dr. Jeff Antol of NASA-Langley, joined Dr. Scott Halliday and six of his students from Navajo Technical College to conduct an experimental Light Detection and Ranging (LiDAR) survey of Four Windows Cave near Grants, New Mexico. Work is underway to combine the LiDAR's laser-based image of the cave with a three-dimensional representation of the topography surrounding the lava tube. This research expedition formed the basis for an on-going education and research relationship between NCKRI's Cave and Karst Studies at New Mexico Tech and Navajo Technical College.

EDUCATION PROGRAM

Education Program Research Expedition

Dianne Gillespie joined NCKRI as its Associate Director of Education at the beginning of this report period. She conducted a research expedition across the USA to learn about current cave and karst programs and to meet with other cave and karst educators to discuss partnership opportunities. Over six months, Ms. Gillespie visited 64 sites including show caves, government agencies, universities, museums, parks, and private groups; see the map below for their locations and names. Forty-five have cave and karst resources open for public tours, and/or conduct educational cave programs.

Discoveries

Of the many museums, aquariums, and science centers toured, 13 locations have a cave and karst exhibit or program. Four advertised specialized educational cave experiences which, for a fee, visitors can arrange a “wild” cave tour. Of those sites, two have canceled those tours due to insufficient funding and one because of White Nose Syndrome (WNS), a deadly condition that has recently devastated bat colonies in southern Canada and the northeastern United States. The American Cave Museum in Kentucky currently conducts a wild cave tour within Hidden River Cave; the cave is owned by the museum’s parent organization, the American Cave Conservation Association

(ACCA).

Eight museums have at least one fabricated cave exhibit; the most extensive and impressive was found in Ohio’s Cincinnati Museum. It provides visitors with a realistic caving trip through both classic limestone caves and an ice cave. While all eight of the cave exhibits rely on interpretative signage to guide the visitor’s experience, only one location has developed educational curriculum, the ACCA’s American Cave Museum.

Thirty-two of the 45 cave and karst sites have established trails and conduct interpretive programs. While three had to close trails temporarily because of WNS, they posted interpretive signs to explain both the resource and closures.

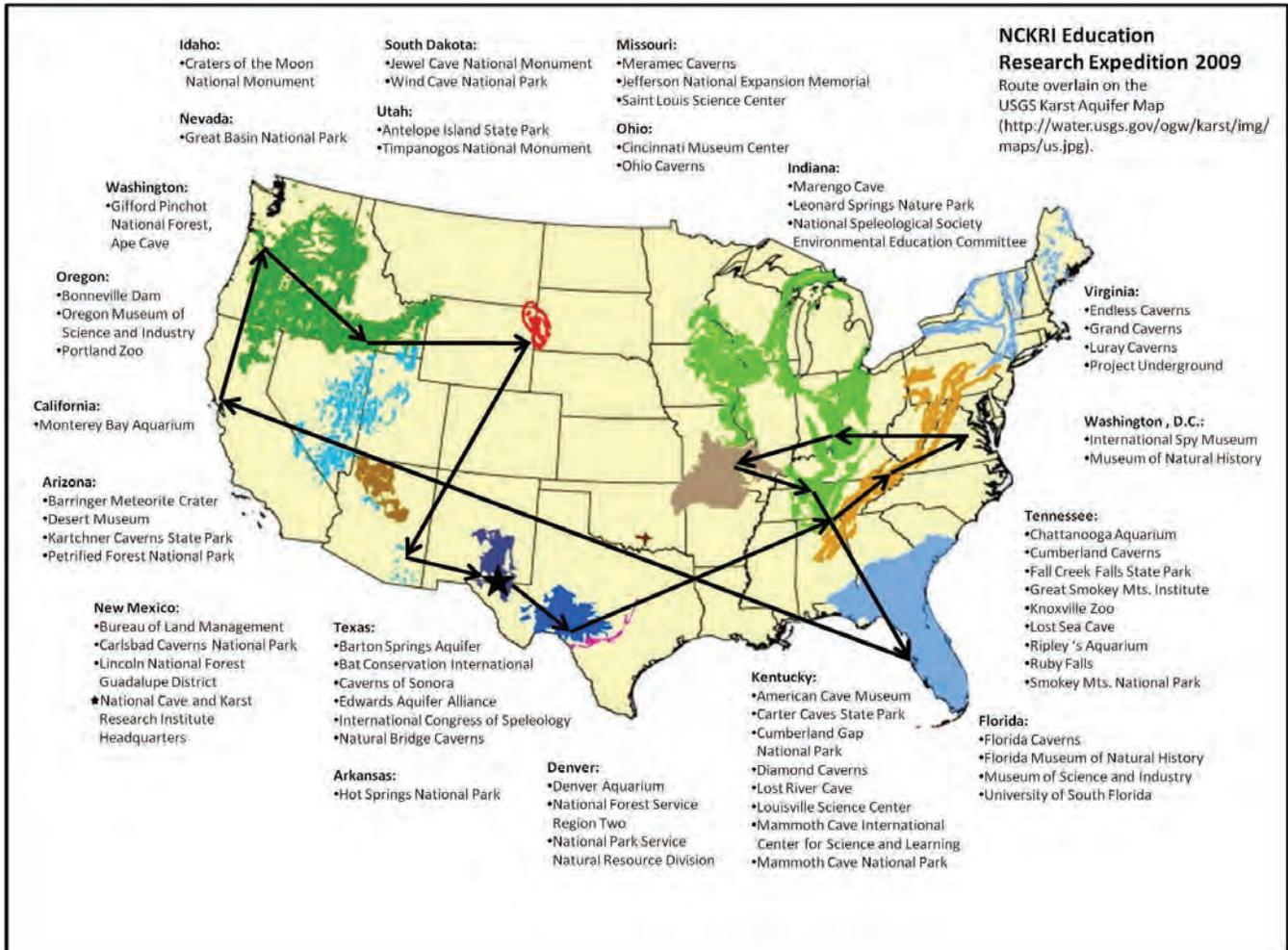




Photo by Dianne Gillespie

Desert Museum's cave exhibit located in Tucson, Arizona.

Effective interpretation connects visitors to a resource, and it was observed that visitors were most engaged, attentive, and actively learning when on guided tours. Three of the locations offered self-guided tours, and two of those offered pre-recorded messages for visitors on self-guided routes. Most of those people began the tour listening to the message, then would lose interest.

While on many guided tours, Ms. Gillespie noted that several provided the public with memorable, but incorrect information. For example, "Did you know that you can create your own species? All you have to do is sign a cave wall, and the microbes that grow on the paint develop only on that paint!" While the guide did tell the group that he would never encourage the group to sign cave walls, his statement carried a stronger message.

While all of the show caves conducted interpretive programs, only a few provided true educational programs. Many locations adjust the general admission cost for school groups, and call the tours "educational." However, in the majority of these locations, the educational tour is the same interpretive tour given to all visitors. Ten locations had an educational specialist who works specifically with school groups. These same locations also have a classroom, either in-cave or on-property, to con-

duct structured lessons. Many of the educational specialists work with teachers to provide in-school instruction prior to visiting the cave, and then conduct "field" lessons on site. Six of the ten educational specialists requested that NCKRI develop training for informal educators, focusing on cave development and explaining karst.

Educational curriculum development in privately owned show caves depends on yearly profits. In publicly managed show caves, staff availability and/or funding is often the limiting factor. Within the group of show caves visited, two privately owned and four publically owned show caves had published curricula. Within them, many of the lessons are essentially the same, only re-worded and re-titled to fit specific locations, thus the diversity of information learned is minimal. Additionally, the curricula typically include lessons on epigenic cave processes, while there were no lessons to demonstrate hypogenic or other earth processes involved with cave development.

Three of the 64 places were organizations that conduct cave and/or karst educational programs: Bat Conservation International (BCI), Mammoth Cave International Center for Science and Learning (MCICSL), and Project Underground (PU). The bulk of BCI's curriculum is about bats, but it also touches on the importance of

caves as bat habitats. MCICSL conducts a variety of programs in coordination with the educational specialists at Mammoth Cave National Park. PU is a two-part cave and karst educational program: curriculum and training. PU curriculum is dispersed to educators who attend PU's training workshops. PU is a national program and has been very successful in its home state of Virginia. One common challenge for these three organizations is insufficient and irregular funding. BCI currently does not have an educational specialist, MCICSL programs depend on grants, and Virginia discontinued funding PU in the Fall of 2009.

Opportunities

Over the course of the research expedition, Ms. Gillespie met with many cave and karst managers, education specialists, and interpretive staff. Every organization encountered was very receptive to NCKRI and the idea of forming partnerships and collaborations on educational activities. From these meetings, good ideas surfaced as potential educational and outreach projects, as illustrated in the following examples.

Multiple museum and science center locations gave great examples for creating innovative and interactive static displays. There were specific ideas for cave and karst programs developed from meeting in Kentucky with ACCA Executive Director David Foster and Education Program Director Peggy Nims. One major idea is that NCKRI's museum and the American Cave Museum (ACM) be



Photo courtesy of the National Park Service
Dianne Gillespie (right) conducting an on-line video Skype meeting inside Mammoth Cave, Kentucky.



Photo by Dianne Gillespie

BLM cave in Utah managed by the National Park Service.

established as “sister” museums. Through such a relationship, NCKRI and ACM could exchange exhibits and curricula and collaborate on grants, program development, and a variety of projects that would benefit both partners’ goals in advancing cave and karst education.

Nationwide, Ms. Gillespie met with multiple managers of privately owned and publicly held show caves. The majority asked NCKRI to establish an ongoing training program for cave guides and to help develop cave and karst curriculum. Show cave managers rely heavily on seasonal employees and thus have high turnover in staff. Funding and staff related factors compound issues related to training and curriculum development. Because millions of people visit show caves nationwide, NCKRI has a great opportunity to educate the public through partnerships and collaboration with the country’s show cave owners and managers.

Ideas to develop internship programs for teachers, cave guides, and recreation managers, arose in discussions with BCI, Gray Fossil Museum

in Tennessee, Great Smoky Mountains Research Institute (GSMRI), and MCICSL staff. GSMRI is interested in partnering with NCKRI to develop a summer youth program and curriculum material focusing on the caves of the Smokies and on WNS.

Within the current depressed economic climate, many program managers presented the idea of combining forces to reduce costs as well as for greater effectiveness. For example, discussions with PU’s Executive Director Carol Zokaite, introduced the prospect for NCKRI to sponsor that program. By taking the lead in developing cave and karst programs in collaboration with established programs, NCKRI may establish itself as the “umbrella” cave and karst education organization. On several occasions, many cave and karst educators and managers asked that NCKRI also serve as a “clearing-house” for cave and karst educational materials.

Application

As a result of this research expedition, gaps in cave and karst education were identified and which NCKRI can fill. NCKRI’s immediate target audience emerged with the weakness of show cave interpretive programs. Ms. Gillespie has also identified existing educational programs interested in NCKRI expanding curricula to include cave and karst topics. The knowledge gained from this nationwide six-month research expedition will be used to establish a strategic plan for NCKRI’s educational program.

Boy Scouts of America

NCKRI is sponsoring a Boy Scouts of America (BSA) venture crew in Carlsbad, New Mexico. A venture crew is a BSA youth development program that gives young men and women positive outdoor experiences that help prepare them to become caring and responsible adults. NCKRI’s Associate Director of Education, Ms. Dianne Gillespie is leading this project.

Developing a Virtual Cave Experience

Ohio State University Ph.D. candidate Christopher Atchison is developing a virtual cave experience for persons with limited mobility. Atchison has assembled a team of mobility-impaired student interns who have no prior in-cave experience. The students will gain cave and karst knowledge through a series of workshops and by going underground. They will later document their experiences in ways that will be analyzed to find common successes and deficiencies in the educational program, and to guide the development of the virtual cave experience. NCKRI is supporting this project with the development of a workshop and by data collection.

The final phase of the project will create a computer-generated virtual reality cave environment at the Ohio Supercomputer Center. This experience will be conducted through the use of three separate virtual environment technologies to determine which methods and virtual features are the most effective for the students’ diverse abilities. They will also provide an innovative and interactive design for virtual reality modeling, moving educational theory for geospatial perception, mobility, and visualization into a solid methodology.

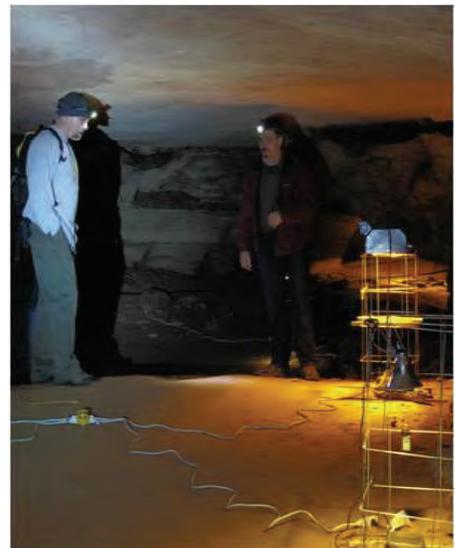


Photo by Dianne Gillespie

Evaluating educational stops along a trail in Mammoth Cave, Kentucky, for the Virtual Cave workshop.

Vista Grande High School Karst Field Experience

NCKRI personnel assisted with a field experience for Vista Grande High School (VGHS), located in Taos, New Mexico. VGHS is an Expeditionary Learning charter school. About 15 years ago, Outward Bound developed a concept for charter schools in which students learn through expeditions—studies outside of traditional classrooms. Currently, 160 schools nationwide offer expeditionary programs.

As the field experience for VGHS's geology course, students studied the geology of New Mexico. A *Roadside Geology of New Mexico* website was

karst and non-karst areas. The presentation also discussed karst groundwater contamination issues and solutions. Mr. Joop gave the students input and provided real stories of groundwater contamination problems he has encountered as an environmental geologist. The third stop was at the exposed Capitan



Photo Courtesy of Vista Grande High School
Mark Joop interpreting the geology of the Permian Reef.

the culminating product for this field experience. Students worked together to develop the website's design and content. Below is a summary of VGHS' two-day visit with NCKRI.

Day 1: Dianne Gillespie, with geologist and NCKRI volunteer Mark Joop, led a field trip around the Carlsbad area. The first stop was at the Flume to discuss karst topography, disappearing streams, the disappearing Pecos River, and resurgence of the river at the Carlsbad Springs. The second stop was a scheduled lunch at the beach along the Pecos River. After lunch, Ms. Gillespie gave a presentation using the karst groundwater model that taught basic principles of groundwater flow in



Photo courtesy of Vista Grande High School
Dianne Gillespie demonstrating a karst hydrology model.

Reef, to discuss reef formation and the local stratigraphy. The day's final stop was in the back reef area to show students teepee structures and pisolith formations. Scientific sampling ethics were also discussed.

During the evening, Mr. Joop gave the presentation, *Responsible Cave Exploration*, which focused on the exploration of

Wolf River Cave in Tennessee. It included a demonstration on cave survey techniques, reinforced responsibility with the concept of "survey as you go" as a caving ethic, and demonstrated vertical caving techniques.

Day 2: The group spent the day in Carlsbad Cavern, examining and discussing many aspects on the origin of the cave. That evening, Ms. Gillespie showed the IMAX movie, *Journey Into Amazing Caves*, led a discussion on different types of caves, and finished with answering questions raised during their daytime activities at Carlsbad Caverns National Park, reinforcing the activities of the previous two days.

"Mentor Me": Bureau of Land Management Youth Initiative Program

NCKRI supported the Bureau of Land Management's (BLM) "Mentor Me" program. Through this program, young men and women in the Carlsbad area complete an internship to gain experiences that help them prepare for the job market. This internship helps youth reach their potential through mentoring relationships with professional adults working within fields of science and land management. Dianne Gillespie spent two days with the "Mentor Me" youth and BLM's Recreation Specialist, Deanna Younger, showing opportunities in education and natural resource management beyond the student's normal range of experience.



Photo courtesy of Deanna Younger
Dianne Gillespie (left) explaining karst processes to "Mentor Me" interns in Cottonwood Cave, Lincoln National Forest, New Mexico.

STUDENT ACTIVITIES

Cave and Karst Studies Program at NMT

Cave and Karst Studies at New Mexico Tech (NMT) is NCKRI's academic program and taught through NMT's Earth and Environmental Sciences Department. A variety of regular courses and special topics are taught by Dr. Penelope Boston on a rotating 2-year frequency, several in collaboration with other faculty (Dr. Tom Kieft, Biology, Dr. Kent Condie and Dr. John Wilson in Earth and Environmental Science) including:

- Cave and Karst Systems
- Cave and Karst Laboratory
- Advanced Topics in Speleohydrology
- Karst Tufa Spring Mound Research
- Model Impact Energetics of Earth and Mars
- Moonmilk Research
- Research Experience on Cave Pearl Origins
- Fundamentals of Geobiology
- Frontiers of Geobiology and Geomicrobiology
- Astrobiology
- Extraterrestrial Dissolutional Landforms
- Astrogeology: Mars and Beyond
- Spaceship Earth: Integrated Global Planetary Science

Dr. Boston currently supervises one Ph.D. student, three Master's students, two undergraduate senior theses, and four independent studies. Ravindra Dwivedi defended his master's thesis on cave micrometeorological modeling and field work in Carlsbad Caverns in December 2009. Andre Richie and Sophia Sigsted will defend their Masters' theses on the Salt Basin Karst Aquifer system in Summer and Fall of 2010.

In addition to the Cave and Karst program students, NCKRI hydrogeologist Dr. Lewis Land served on the Master's committee of NMT geology student, Jeremiah Morse. Mr. Morse graduated in Spring 2010 after



completing his thesis on groundwater residence time in the karstic San Andres and Yeso aquifers in the southern Roswell Artesian Basin, New Mexico.

During the 2009-2010 year, researchers and students of the Cave and Karst Studies program have engaged in excellent and exciting research, surpassing last year's record number of new and ongoing projects. With extensive grant submission activities and management supported by Lisa Majkowski and laboratory supervision by Dr. Rasima Bakhtiyarova, the program has set the standard at New Mexico Tech.

Student Projects

Sulfuric Acid Caves and Sulfur Springs of Tabasco, Mexico

Ph.D. student Laura Rosales-Lagarde continues her research on the origins of the hydrogen sulfide and other gases and waters flowing into Cueva de Villa Luz and other sulfur caves and springs in the region of southern Tabasco, Mexico. Ms. Rosales-Lagarde anticipates completion of her dissertation in Fall 2010.

Since the late 1990's, Cueva de Villa Luz has drawn

increasing attention from cavers and scientists. Dripping with sulfuric acid, and with frequently deadly concentrations (to humans) of hydrogen sulfide (H_2S), carbon monoxide (CO), and other gases in the air, the cave has boasted a stunning array of microbial and higher life forms. These organisms are ultimately living off the oxidation of H_2S gas as the base of the food chain.

Dr. Penelope Boston has been working on various aspects of the system since 1998 and one of the great puzzles has been the source or sources of the hydrogen sulfide and other gases. Are they volcanic? There is a nearby volcano, El Chichon, that erupted last in 1982. Is the sulfide derived from some sort of subsurface rock source? The answer to this question is critical for proper interpretation of both the geochemistry and unique biology of the system. This is the problem that Laura Rosales-



Photo by Kevin Stafford

Laura Rosales-Lagarde teaches the ecology and conservation of Cueva de Villa Luz to high school students in Tapijulapa, Tabasco, Mexico.

Lagarde chose for her Ph.D. work as a NCKRI Scholar.

Ms. Rosales-Lagarde has made major strides in our understanding of the geochemistry and structural geology of the system. In summary, there are complex structural controls that have produced two separate hydrological systems:

- a shallow, meteorically-driven system with fresh water and low or no concentrations of H₂S, CO, CO₂, etc., and
- a deep briny and gas-rich anaerobic aquifer.

These two hydrologies meet and mix in the cave, in some other nearby sulfidic caves, and in a number of surface sulfide springs in the area. The co-mingling of these distinct waters may be largely responsible for the amazing biomass production and species diversity within Cueva de Villa Luz.

The sources of the different gases are numerous. They include reduction of evaporites (mainly gypsum, CaSO₄) from layers located below the limestone in which the cave is formed. This reduction may be thermal or biological in origin, but sulfur isotopic values tend to support a mi-

crobial interpretation. Pyrite within thin shale layers also serves as a source of some sulfide. Brines, associated with petroleum production in the surrounding area, also appear to contribute to the overall unusual gas environment of the caves and springs. Lastly, the volcanic activity in the area does contribute perhaps as much as 15% of the gas, at least episodically. The gas composition of the cave can vary on timescales as short as seconds to as long as days. The episodicity of gas emissions from the over thirty springs within the cave does not seem to depend on season (wet versus dry), or on other features of seasonality like temperature.

Careful mapping and structural analysis of the area has revealed some clues to the hydrological and geochemical behavior and sources. In addition, this information is also useful in understanding the routes of fluid migration of petroleum as well as water. Besides the intrinsic scientific value of the study as applied to the caves, the results of this research will help illuminate the behavior of a large number of springs (over 50) in the area that are of significance to the local populations.

Mt. Erebus Ice Caves

Since 2005, NCKRI student Aaron Curtis has been involved in projects mapping limestone caves and disentangling microclimate processes for fun and science. Beginning in the Fall of 2009, the Mount Erebus Volcano Observatory run by New Mexico Tech has given him a new opportunity to apply those techniques to investigate a truly unique phenomenon: Fumarolic Ice Caves (FICs) and Fumarolic Ice Towers (FITs) of Erebus Volcano, Antarctica.

Around two hundred FITs and FICs are scattered around the summit caldera. FICs are networks of tunnels, some several hundred meters long, melted into the bottom of the snow-pack by heating from below and containing volcanic gasses and a great variety of extraordinary ice crystals. They are related to towers, rising up to 30 m from the surface of the snow, which form when the water-rich volcanic gasses are released into Erebus' -35 C° degree atmosphere.

Mr. Curtis is co-advised by volcanologist Dr. Phillip Kyle of NMT and Dr. Penelope Boston of NCKRI. In his first field season, November 2009 to January 2010, he gathered data and samples to answer questions regarding the processes that form FITs and FICs, what they can tell us about the plumbing of the volcano, and whether these environments harbor microbial life.

With the help of the Erebus Observatory team and field assistant Nial Peters, Mr. Curtis placed 22 dataloggers in the caves, which will record microclimate parameters for at least a year, assuming they endure the Antarctic conditions. At the end of the field season, the team retrieved seven cores from FIT walls to check for magmatic water and hydrothermal components by hydrogen and oxygen isotope analysis using NMT's new laser cavity ringdown mass spectrometer, as well as several gas samples for analysis on a gas chromatograph. Survey and mapping efforts produced complete three dimensional maps of five caves.

Microbial contents of the samples



Photo by Penelope Boston

Laura Rosales-Lagarde collecting water samples in the rimstone dam area of Cueva de Villa Luz, Tabasco, Mexico.



Photo by Nial Peters, courtesy of Aaron Curtis
Aaron Curtis surveys Warren Cave, a fumerolic ice cave, Mt. Erebus, Antarctica. A transit had to be used because underlying magnetite made compasses useless.

are being prepared for analysis. Besides working with Dr. Boston, Mr. Curtis will also be collaborating with Dr. Tom Kieft of the NMT Biology Department.

Tasks for the 2010 to 2011 field season will include returning to Antarctica in November 2010, downloading dataloggers, re-mapping several of the caves to look for geometric changes, and completing a catalogue of all cave entrance locations on the volcano. The project, including an interview with Mr. Curtis, will be featured in the BBC's upcoming documentary, *Frozen Planet*, to be broadcast in Fall 2010.

Cold, Dark Microbial Life

Celeste Asikainen is a visiting Ph.D. geology student and a NASA Planetary Biology Intern (PBI) at the University of Massachusetts Amherst. The NASA PBI program provides funding for students to work with NASA-supported faculty such as Dr. Penelope Boston. Ms. Asikainen's research focuses on the geomicrobial processes in concretions in the bottom of the dark cold zone of Connecticut lakes. She is working with Dr. Boston to compare these lake samples to geomicrobial concretionary processes in cave deposits.

Paleohydrology and Climatology

Kristina Morgan is a new graduate student whose Master's thesis will examine the hydrological and climate history of Fort Stanton Cave's Snowy River Passage. She will analyze the highly structured mud deposits in Mud Turtle Crawl, the main passages and in Snowy River itself, and by looking at dateable materials and clues to above-ground vegetation. (See pages 5-6 for more details on Fort Stanton Cave.)



Photo by George Veni
Smooth and irregular cave concretions, Scarisoara Ice Cave, Apuseni Mountains, Romania.

Interstate Stream Commission Salt Basin Project

Andre Ritchie and Sophia Sigsted completed their work on the karst hydrology and water resource potential of the Salt Basin in southern New Mexico and west Texas. This project was funded by New Mexico's Interstate Stream Commission (ISC) and supervised by Dr. Fred Phillips, NMT, and Dr. Penelope Boston, NCKRI. Their report for the ISC is summarized here.

The Salt Basin region has a long and complex geologic history that makes its hydrologic interpretation complex. Four main episodes of deformation from the Pennsylvanian Period to the Cenozoic Era affected the deposition of the rocks and their distribution within the basin.

The primary aquifer units occur in Permian age rocks deposited on a shallow marine shelf next to the deep Delaware Basin to the southeast. These are the San Andres and Yeso formations, which transition to the Victorio Peak and Bone Spring formations toward the southeast. These units are hydraulically connected and their permeability is highly dependent upon fracture density, as is typical of karstic systems.

Groundwater flow is concentrated in fractures and solution channels formed in limestones and dolomites. Interbedded, less permeable units act as barriers to groundwater flow, causing groundwater to occur at different levels within the same formation. Perched

aquifers occur in localized Cretaceous age deposits above the regional Permian aquifer, and also in alluvial deposits associated with ephemeral drainages. A zone of high permeability extends from the southern Sacramento Mountains southeast toward Dell City, Texas. Low hydraulic gradients extending northward from the Dell City region suggest high permeabilities in the Permian

and valley fill aquifers.

The research methods include use of natural tracers in water, especially radiogenic carbon, and a structural basin analysis. The water chemistry is consistent with groundwater evolution starting in the Sacramento Mountains and moving south to where it discharges at the Salt Flats near Dell City. The eastern part of the basin has a distinct flow path where a complete dedolomitization process occurs (the natural removal of magnesium from dolomite, converting it to limestone). This groundwater reaction involves dissolution and precipitation of carbonate minerals and changes in chemistry that require adjustment of ^{14}C values for more accurate age estimations. Along well-defined flow paths, radiocarbon dated water ages were used to calculate average seepage velocities that range from approximately 3,000 to 17,000 years.

Sulfur-34 isotope ratios were able to largely constrain the magnitude of the flow to the San Andres and possibly upper Yeso Formation. By using well logs or geologic cross-sections along a defined flow path, the volume of flow through the aquifer was determined. Although permeability is high, the change in volume through the eastern side of the basin is only about 13.6 million m^3/year (11,000 acre-ft/year), probably due to the thin nature of the San Andres and the Yeso in this basin. The aquifer thickens toward Dell City, which could explain why significant drawdown of water levels have only been observed during times of exceptionally high pumping rates, such as in 2000 when pumping totaled more than 247 million m^3 (200,000 acre-ft).

The deuterium and oxygen isotope analyses show paleo-groundwater present in the vicinity of Crow Flats and Dell City. This implies that while there is a large volume of recoverable water in the basin, a significant amount of it was recharged in the late Pleistocene Epoch, more than 10,000 years ago. Thus, some of the water is essentially being mined out, as it is not actively recharging. All of these factors will play important roles in the development of a thoughtful approach to future water management in the Salt Basin.

Student Support at Other Universities

NCKRI's broader educational outreach efforts extend to universities outside of New Mexico Tech. General support through information is provided to many students. Formal support is currently provided by Executive Director Dr. George Veni, who serves on the committees of two students at The University of Texas at San Antonio (UTSA), and one student at Harokopio University, Athens, Greece. Their projects are summarized below.

Mulch Fire and Groundwater Contamination in Texas

Kyle Cunningham successfully defended her Master's thesis in July 2009, completing her degree in environmental science. Her thesis examined the impacts on groundwater quality by extinguishing a giant mulch pile fire on the karstic Edwards Aquifer recharge zone (where water flows into and replenishes the aquifer). Ms. Cunningham also developed protocols for more effective groundwater quality monitoring of private wells drawing from karst aquifers.

Thermal Imaging of Caves

Keith Muhlestein is completing his first year as a geology doctoral student. His dissertation will study thermal imaging of caves and karst features and its application to environmental assessments of karst areas. During the past year he has placed data loggers in Logan's Cave, in northwest Bexar County, Texas, to monitor barometric pressure and temperature changes that will be instructive in sampling for and collecting thermal images. NCKRI board member Dr. Ron Green assisted Mr. Muhlestein with an electrical resistivity survey of Friesenhahn Cave, a major paleontological site in the region that may also become part of the study.

GIS Evaluation of a Mixed Limestone and Gypsum Karst, Greece

Miljana Golubović Deligianni's Ph.D. dissertation focuses on geographic information system (GIS) modeling to improve understanding and land use of the Ksiriomero region of western Greece. Her study area is characterized by limestone mountains surrounding gypsum plains and hills dotted with alluvium-filled sinkholes and poljes (large, flat-floored sinkholes).



Photo by George Veni

Agriculture in Greece's Ksiriomero region occurs mostly in poljes—giant, flat-floored sinkholes. Water is piped-in over the mountains and stored in excavated basins dug into the poljes' clay-rich floors.

OUTREACH

Professional Meetings

NCKRI attended, sponsored, and/or had a booth at numerous conferences during the past year:

- 4th International Workshop on Ice in Caves, Obertraun, Austria.
- 15th International Congress of Speleology, Kerrville, Texas.
- American Geophysical Union convention, San Francisco, California.
- American Planning Association Conference, New Orleans, Louisiana.
- Astrobiology Science Conference Houston, Texas.
- Decade of Discovery: National Landscape Conservancy System Symposium, Albuquerque, New Mexico.
- Geological Society of America (GSA) Convention, Portland, Oregon.
- International Conference on Bioinformatics and Computational Biology, Honolulu, Hawaii.
- New Mexico Geological Society Fall Field Conference, Socorro, New Mexico.
- Texas Archeological Society Convention, Del Rio, Texas.

Additionally, NCKRI staff organized or co-organized several events:

- Dr. Boston co-chaired a session, *Integrating Karst and Planetary Volcanology*, and led a field trip, *Lavatubes of the Mount St. Helen's Region: Geology, Biology, and More!* at the 2009 GSA Convention. This field trip was co-sponsored by GSA and NCKRI.
- Dr. Land co-chaired the cave and karst geology session of the 15th International Congress of Speleology.
- Dr. Veni co-chaired the 2009 GSA session, *Volcanic Caves: Geological and Microbiological Terrestrial Analogs of Potential Extraterrestrial Conditions* with Dr. Carl Allen of NASA.

15th International Congress of Speleology (ICS)

Of all of the conferences NCKRI attended and sponsored since its creation, the 15th ICS was the most significant. NCKRI was the major sponsor of this quadrennial event, held this time in Kerrville, Texas, and its staff worked on it for over 6 years. Current NCKRI Executive Director Dr. George Veni served as ICS Chairman and past Executive Director Dr. Louise Hose was Vice-Chairman. NCKRI board members, partners, and other staff also joined the hundreds of national and international volunteers who made the event possible.

The 15th ICS was combined with the 2009 National Speleological Society (NSS) Convention and hailed as the best ICS ever and the most significant caving and cave science event in North America. Following is a summary of its results:

- Registration: 1,567.
- Countries represented: 52.
- Three proceedings volumes totaling 2,130 pages from 501 papers.
- 15 special symposia addressing the state-of-the-art in cave and karst science and data management.
- 29 oral and poster sessions covering all aspects of cave exploration, science, and management.
- 21 workshops, classes and forums.
- 18 meetings of the NSS and its internal and affiliated organizations.
- 24 meetings of the Union Internationale de Spéléologie (UIS) and its internal and affiliated organizations.
- 15 social events.
- First display of the world's largest cave maps of four of the world's five longest caves.
- Six full days of caving videos and 3 -D slide slows.
- Over 50 activities for children.
- Eight evening field trips.

- 57 cave, cave science, and cultural/tourist trips.

- 13 pre and post-ICS trips to three countries and 12 U.S. states.

At the close of the ICS, Dr. Veni was elected UIS Vice President of Administration. His primary duties will be to coordinate all of the UIS Commissions, Departments, and Working Groups, and to mentor the staff of the 16th ICS, which will be held in Brno, Czech Republic, on 21-28 July 2013.

Guest Lectures by NCKRI

NCKRI's Drs. Boston, Land, and Veni and Ms. Gillespie were invited to give the following presentations and lectures:

- *She's an Astronomer* Workshop hosted by The Albuquerque Astronomical Society that featured motivational presentations by renowned female scientists as encouragement for young women in Grades 1 through 12 to pursue education and careers in Astronomy-related fields. The workshop was well attended



Photo courtesy of Bill Frantz
At the close of the 15th ICS, Chairman Dr. George Veni (left) presents the UIS flag (in bag) to 16th ICS Chairman Zdenek Motycka.

and the presenters addressed 380 students plus their parents.

- Lecture on extraterrestrial caves and lava tubes given to the Albuquerque Astronomical Society.
- Presentation on Naica Cave to the Deming Mineral and Gem Society.
- Presentation to Jet Propulsion Laboratories on caves in the solar system.
- Presentation to the Modesto Junior College on cave science.
- Decade of Discovery meeting in Albuquerque, New Mexico, sponsored by the BLM to publicize research in BLM-designated National Conservation Areas (NCAs) as part of their National Land Conservation System. Dr. Land presented results of research efforts at Fort Stanton Cave, which was designated an NCA in 2009. Dr. Boston and NCKRI board member Dr. Diana Northup, UNM, presented results of their microbiological research at Fort Stanton Cave. These lectures helped stimulate additional funding from BLM in June 2010 for NCKRI to conduct more research at the cave.
- Presented the results of the previous two years of research at Fort Stanton Cave at the Spring 2010 meeting of the New Mexico Geological Society (NMGS), which included results of resistivity surveys over the northern extension of the Snowy River passage (see pages 5-6).
- Exhibited a map of the regional water table in the southern Sacramento Mountains as a poster at the NMGS spring meeting in Socorro, developed in collaboration with New Mexico Bureau of Geology and Mineral Resources colleagues in Socorro and Albuquerque (see page 8).
- Bottomless Lakes State Park lecture on karstic aquifer systems in the Roswell Artesian Basin, and the relationship of the Bottomless Lakes sinkholes to the regional hydrologic framework in the Artesian Basin. Dr. Land has given variations on this presentation for

the Park's Enchanted Evenings program every summer for several years, establishing a long-term relationship with this New Mexico state park, which plays an important role in the hydrologic framework of the lower Pecos region.

- Lecture for the Roswell Geological Society on the occurrence of anthropogenic sinkholes in the Delaware Basin region of southeastern New Mexico.
- Presentation on regional hydrology and karstic aquifers of southeastern New Mexico, given at Washington Ranch, south of Carlsbad, for cavers and cave scientists attending a post-ICS Guadalupe Mountains field camp.
- Lecture for the 18th International Karstological School, Postojna, Slovenia: *Hydrogeologic controls on the evolution of the Edwards Plateau Karst, Texas, USA.*
- Lecture for Leadership Carlsbad program, *Karst aquifers and their management: a primer*, Carlsbad, New Mexico.
- Presentations on NCKRI's status, progress, and plans were given in Carlsbad, New Mexico, to the Carlsbad Chapter of AARP and Carlsbad Downtown Lion's Club, in Albuquerque, New Mexico, at the Winter Technical meeting of the Southwestern Region of the NSS, and in San Antonio, Texas, for the Bexar Grotto chapter of the NSS.
- Presentation on NCKRI Headquarters' artificial bat roost for a bat conservation workshop led by Bat Conservation International and hosted by the U.S. Forest Service in Carlsbad, New Mexico (see page 25).



Photo by George Veni

Trails lead to water that fill the bottoms of collapse-formed sinkholes at Bottomless Lakes State Park, New Mexico. The sinkholes result from rising groundwater in the Roswell Artesian Aquifer that discharges along the Pecos River.

Co-Hosted and Co-Sponsored Speakers

- NMT's Earth and Environmental Science Department, the New Mexico Bureau of Geology and Mineral Resources, and NCKRI joined to host a guest lecture by Dr. Andreas Pflitsch of Ruhr University, Department of Geography, Workgroup Cave and Subway Climatology, Germany. Dr. Pflitsch's presentation, *Comparing the Structure of Air Flow and Temperature Patterns of Barometric Caves and Blow Holes – a Perfect Instrument for Determining the Real Extension of Barometric Cave Systems*, focused on using climatological measurements and air volume analyses to determine the potential extent and connectivity between Jewel and Wind caves in South Dakota, as well as between Carlsbad Cavern and Lechuguilla Cave, New Mexico.
- NCKRI co-sponsored the Edwards Aquifer Authority's day-long Distinguished Lecture Series workshop in San Antonio, Texas. The sold out October 2009 lecture was on *Karst Science in the 21st Century: Accomplishments and Directions* by Dr. William B. White and Dr. Elizabeth L. White, Emeritus Professors from the Pennsylvania State University.

Partnership Meetings

Karst Institute Agreements

NCKRI signed memoranda of understanding with three prominent international karst research institutes:

- The Emil Racovita Speleological Institute (ERSI) has offices in Bucharest and Cluj, Romania. It is named after the early and highly influential Romanian cave biologist and is the world's oldest cave and karst research institute, founded in 1920. ERSI has a decades-long history of producing excellent cave and karst research and reports.
- The Karst Research Institute is located in Postojna, Slovenia (see photo below) and was founded in 1947. In addition to its distinguished series of research reports, it has hosted the International Karstological School since 1993, and publishes *Acta Carsologica*, one of the world's most prominent cave and karst journals.
- The Ukrainian Institute of Speleology and Karstology (UISK) is a relatively young institute, founded in 2006, but is highly productive and has close ties to NCKRI. UISK Director Dr. Alexander Klimchouk is a former NCKRI Visiting Scholar (2006-2007) and NCKRI co-sponsored UISK's *International Conference on Hypogene Speleogenesis and Karst Hydrogeology of Artesian Basins* in Chernivtsy, Ukraine, in 2009.

The memoranda formally establish collaborative and mutually beneficial relationships to better meet the goals of all four institutes.

Department of the Interior Briefing

The U.S. Department of the Interior's (DOI) Deputy Assistant Secretary of Science and Water, Deanna Archuleta, hosted a briefing by NCKRI and its DOI partner agencies on current cave and karst research and management issues. Presentations were made by NCKRI Executive Director Dr. George Veni, board members and national cave resources leads Jim Goodbar (Bureau of Land Management), Dale Pate (National Park Service), and Dave Weary (U.S. Geological Survey), and by David Kampwerth (U.S. Fish and Wildlife Service), who was elected to the NCKRI board a few days later during the May 2010 board meeting.

Cave Management Planning

Dianne Gillespie was invited to join a U.S. Forest Service (USFS) cave and karst management plan writing committee. USFS National Cave Resources Coordinator, and former NCKRI board member, Jerry Trout, is developing the plan for the Guadalupe District in New Mexico's Lincoln National Forest. It is expected to become the USFS national cave and karst management plan.

Community Involvement

NCKRI staff:

- Judged the Carlsbad Municipal Schools Science Fair in October, 2009, and joined BLM to judge a science fair at Loving Middle School, Loving, New Mexico.
- Assisted in a "clean-up" project at BLM's Hackberry Lake Day Use site, near Carlsbad, New Mexico.
- Participated in the Carlsbad Chamber of Commerce's annual *Bat Brigade*, a delegation of community leaders who travel to Santa Fe, New Mexico, during the state congressional sessions to meet with state governmental leaders and raise their awareness and support for issues in the City of Carlsbad and in Eddy County.
- Briefed Drew Stout (field representative for U.S. Congressman Harry Teague), Allyson Anderson and Lynn Ditto (assistants to New Mexico Senator Jeff Bingaman), Peter Folger (Congressional Research Service), and Linda Rowan (American Geological Institute) on the anthropogenic sinkhole collapses associated with brine wells in southeastern New Mexico and west Texas (see page 7).
- Joined a team of federal agencies (BLM, National Park Service, and USFS), to sponsor and participate in *Relay for Life*, a nationwide campaign to raise awareness and funds to fight cancer.
- Regularly attended meetings of the Carlsbad Chamber of Commerce, Carlsbad Department of Development, and Carlsbad Rotary Club.
- Served on a special committee for Dr. Sheri Williams, Superintendent of Carlsbad Municipal Schools (CMS). The committee developed a plan to competitively position Carlsbad in the America's Promise Alliance "Top 100 Communities for Young People" program. It also established a plan to increase the CMS graduation rate from the present 64% to 90% by 2014.
- Assisted the Carlsbad Department of Development in getting a grant to complete the construction of the canal in the Cascades of Carlsbad urban redevelopment project.



Photo by George Veni

Karst Research Institute headquarters, main plaza, Postojna, Slovenia.

Education

OASIS Course on Caves and Karst

OASIS is a national organization dedicated to enriching lives of adults age 50 and older through lifelong learning and service. Dr. Penelope Boston taught a short course on cave and karst science to a full auditorium of seniors at the OASIS Albuquerque branch.

New Mexico Tech Mars Field Course for Science Teachers

NCKRI's Dr. Penelope Boston and Lisa Majkowski, along with Michael Spilde, University of New Mexico (UNM), and Dr. Liza Coe, NASA-Ames, conducted a new Master of Science Teaching course designed for high school science teachers. This interdisciplinary field course is based out of the Mars Desert Research Station (MDRS) in Hanksville, Utah. It provides an integrated program of geology, mineralogy, biology, microbiology, planetary science, and observational astronomy.

This year's course began at New Mexico Tech with classroom lectures on cave and karst science, laboratory protocols, and field safety. The group then proceeded to the El Malpais lava tube caves near Grants, New Mexico. The teachers sampled microbial material from the cave walls and from the moss garden at Four Windows Cave. The group then proceeded to MDRS, where teachers conducted field experiments in spacesuit mockups and extraveicular expeditions on ATVs to nearby geological features and biological sites. On an exciting trip to Crystal Geyser, a cold CO₂ spring on the Green River in Utah, the group found an extensive travertine deposit and spherical concretions dubbed "non-cave pearls" that bore a remarkable resemblance to cave pearls. The course ended with scanning electron microscopy and Fourier transform infrared spectroscopy analyses at UNM.

Support for this course was provided by NASA through the New Mexico Space Grant Consortium, the NASA Spaceward Bound Program and NASA-Ames, the New Mexico Tech Science Teachers Program, the Mars Society, and NCKRI.

Media

Dr. Penelope Boston:

- Gave an interview to the British Broadcasting Corporation (BBC) on life in caves.
- Gave an interview about an Albuquerque Journal story on Snowy River Passage in Fort Stanton Cave, New Mexico (see pages 5-6).
- Was featured in Richard Dindo's film, *The Marsdreamers*, which opened in Europe in February 2010 (http://www.planete-mars-suisse.com/crbst_22.html). This documentary examined the reasons and realistic chances of traveling to Mars; a topic that until recently has been limited to science fiction. Dr. Boston was interviewed at Valley of Fires lava field near Carizzozo, New Mexico, about astrobiological science and lava tube caves on Mars.
- Was highlighted in a new television special with Phil Platt about her work with extremeophiles, species adapted to extreme living conditions, in Spider Cave, Carlsbad Caverns National Park, New Mexico. This special is scheduled for broadcast on the Discovery Channel in Fall 2010.
- Starred in the much anticipated National Geographic sequel to the *Giant Crystal Cave*. It will be aired in the U.S. and Canada in October and December of 2010. This production revisits Naica Cave (see page 7) and presents new information about the microbiology of this amazing and unique cave system.

Dr. George Veni:

- Was interviewed for several Texas newspapers about the 15th ICS, which he chaired in Kerrville, Texas (see page 20).
- Gave a preview to the Carlsbad Current-Argus of the sculpture of Jim White, early explorer of Carlsbad Cavern, which will be unveiled in front of NCKRI Headquarters in late 2010.
- Was interviewed by local and national newspapers about a potential brine well collapse in Carlsbad (see page 7).
- Was interviewed for Albuquerque and Roswell, New Mexico, television news stations about the artificial bat roost being constructed at NCKRI Headquarters.
- Gave an interview to Romanian television news networks on the importance of Scarisoara Ice Cave, Romania.

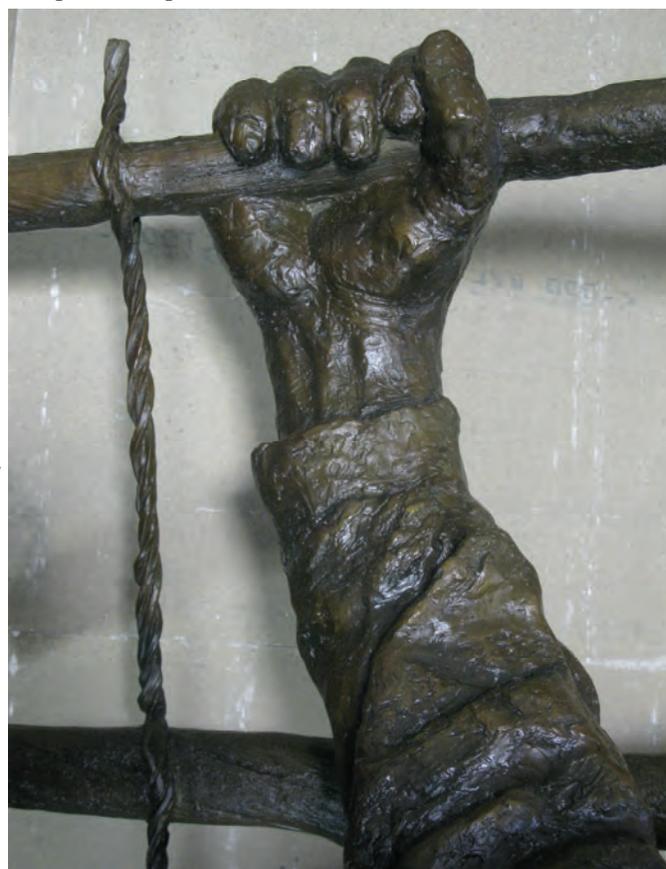


Photo by George Veni

Preview of the Jim White sculpture—his hand grasps a wire and sticks ladder as he descends into Carlsbad Cavern.

BOARD ACTIVITIES

The NCKRI Board of Directors met in October 2009 in Portland, Oregon, in conjunction with the Geological Society of America Convention, and in May 2010 at the headquarters of the U.S. Geological Survey in Reston, Virginia.

Below are some of the Board's activities during the past year:

- Approved NCKRI grant guidelines; the grant program will be started at a later date as funds allow.
- Separated the Education Committee from the Research and Education Committee to allow more oversight of the Education Program at NCKRI now that there is an Education Director; the committee's first task will be to review the Education Program's Strategic Plan being prepared by the Education Director.
- Approved the Executive Director's template for Memoranda of Understanding (MOUs) with other cave and karst research institutes; each MOU will be approved by the Board.
- Applied for NCKRI membership within the American Geological Institute.
- Approved purchasing policies and procedures for funds received directly by NCKRI, not via NMT.



Photo courtesy of Larry Pardue

NCKRI Headquarters under construction, 22 November 2009.

Hazel Medville, Chairman

Member since 2005, Chairman since 2006, Bachelor's Degree in Statistics and Computer Science. Hazel is a retired Computer Engineer/Manager who now spends much of her time surveying caves in Hawaii and Colorado. She was the President Pro-Tem and Government Liaison for the National Speleological Society, the Technical Program Chairman for the 15th International Congress of Speleology, and is currently the Director of the West Virginia and Hawaii Speleological Surveys. In 2003 Hazel was honored to receive the William J. Stephenson Outstanding Service Award from the National Speleological Society in recognition of her long term contributions to the society.

Dale Pate, Vice-Chairman

Member from 2000-2002; 2006 to present, and Vice-Chairman since 2006. Bachelor's Degree in Geography. Dale has been the National Park Service Acting Cave and Karst Program Coordinator since May 2007, and the Supervisory Physical Scientist (Cave Specialist) at Carlsbad Cavern National Park since July 1991.

Richard Cervantes, Secretary/ Treasurer

Member since 2005; permanent position representing New Mexico Tech. Master's Degree in Accounting and Information Systems, and is also a CPA. Richard is the Associate Vice President of Research and Eco-

BOARD OF DIRECTORS

nomics Development with New Mexico Tech. He is responsible for administrative affairs including budget preparation, fiscal and project management, proposal development and contract negotiation.

Dave Steensen

Member since January 2009; permanent position representing the National Park Service; Bachelor's Degree in Geology and a Master's Degree in Environmental Systems/Applied Geology. Dave is the Chief of the Geologic Resources Division of the National Park Service. One of his responsibilities as Chief is oversight and support of the Service-wide cave and karst resource management program.

Harry Burgess

Member since 2005; permanent position appointed by the Mayor of Carlsbad, New Mexico; Bachelor's Degree in Industrial Relations, Master's Degree in Fire and Emergency Management Administration; Master's of Business Administration. Harry represents the City of Carlsbad in its participation with NCKRI. He is Carlsbad's City Administrator but also has a caving background, having worked previously with the National Park Service and served on the Board of the National Cave Rescue Commission. He also taught caving for the National Outdoor Leadership School.

Todd Chavez

Member since 2009; Master's Degree in Library and Information Science. Todd is the Director of Academic Resources at the University of South Florida Tampa Library. His research agenda focuses on understanding scholarship in the sciences including the tools and processes underlying its creation, organization, discovery, communication, and preservation. Activities include building non-

traditional library collections to support scientific research and publication, and applying bibliometric research methodologies to document and “visualize” scholarship in the sciences. He is the Operations Manager and one of the founding partners of the Karst Information Portal.

Dr. Ronald T. Green

Member since 2007; Bachelor’s in Industrial Engineering; Bachelor’s in Geology; Master’s in Geophysics; Ph.D. in Hydrology. Ron is a hydrogeologist with the Southwest Research Institute, San Antonio, Texas, where much of his work focuses on karst aquifers.

Jim Goodbar

Charter board member; Bachelor’s Degree in Park and Recreation Management, also Graduate Studies in Cave and Karst Resources, Geology, and Geomorphology. Jim works for the U.S. Bureau of Land Management (BLM) as the Senior Cave and Karst Resources Specialist with the Washington Office. Jim also serves as the BLM New Mexico State Cave Coordinator and as the Senior Cave and Karst Specialist for the BLM Pecos District and the Carlsbad Field Office. His duty station is located in Carlsbad, New Mexico. His primary responsibilities are to establish policy and provide guidance on cave and karst resources management to BLM field offices across the United States, serve as the international point of contact for all cave/karst related issues and requests for assistance, develop and conduct training courses for cave/karst resources, and develop best management practices for land use actions in karst lands.

Dr. John (Jack) Hess, Member at Large

Member since 2005; Member at Large of Executive Committee; Ph.D. in Geology. Jack is the Executive Director of the Geological Society of America (GSA). Prior to joining GSA in 2001, he was Executive Director of the Division of Hydrologic Sciences and Vice President for Academic Affairs at the Desert Research Institute in Nevada.

Jack currently serves on the board of the Karst Waters Institute, and Longs Peak Council of the Boy Scouts of America, as well as NCKRI. Jack is a Fellow of the Geological Society of America, the National Speleological Society, and the Cave Research Foundation.

Ronal Kerbo

Member since June 2009, Cave and Karst Resources Specialist for the U. S. National Park Service (NPS) for 31 years until March 2007. Ron retired from the NPS as the National Cave and Karst Program Coordinator and the acting Director of NCKRI.

Dr. Kathleen Lavoie

Member since 2006; Ph.D. in Biological Sciences. Kathleen is a Biologist and Professor and Dean of the Faculty of Arts and Sciences at the State University of New York College at Plattsburgh. Since 1974, she has studied the biology of animals that live in caves. Her research deals with microbiology, geomicrobiology, cave crickets, sulfur cave systems, and invertebrate ecology with a smattering of work on bats. Kathy was honored to receive the Science Award from the National Speleological Society in 2007 in recognition of her long term contributions to cave science.

Dr. Diana Northup

Member since 2006; Ph.D. in Biology. Diana is Professor Emerita in the University Libraries at the University of New Mexico and a Visiting Associate Professor of Biology, Albuquerque, New Mexico. Since 1984, she has studied organisms that live in caves. Diana and her colleagues on the SLIME (Subsurface Life In Mineral Environments) Team investigate microbial interactions with rock surfaces in caves and in desert varnish.

Geary Schindel

Member since 2004; Bachelor’s Degree in Geology and a Master’s Degree in Geography. Geary is the Chief Technical Officer of the Edwards Aquifer Authority in San Antonio, Texas and di-

rects the Aquifer Science Research Program. The Edwards Aquifer is a major karst aquifer that provides water to more than 1.7 million people in south-central Texas.

Dr. H. Len Vacher

Member since 2005; Ph.D. in Geology. Len is a Professor of Geology at the University of South Florida where he taught hydrogeology and studied young carbonate islands experiencing diagenesis (settings for eogenetic karst). His teaching and sponsored research now focus on cross-curriculum quantitative literacy and math concepts for geologists. One of the founding directors of the National Numeracy Network, a non-profit membership organization promoting quantitative literacy, he is now a managing editor of its new open-access journal, *Numeracy*.

David Weary

Member since June 2009, Bachelors Degree in Geology from George Mason University and a Masters in Geology from Virginia Tech. David has worked for the U.S. Geological Survey (USGS) in Reston, Virginia, since 1988 and now serves on the NCKRI Board as the USGS representative. He is a research geologist and Project Chief of the USGS KARST Project. The Project is involved in various activities including karst studies and geologic mapping in the Ozarks of Missouri, as well as geologic mapping, and hydrogeologic studies in the Shenandoah Valley of Virginia and West Virginia. In addition, the Project is also working on a new national karst map in cooperation with the National Speleological Society and NCKRI.

NOTE:

Near the end of this past year:

- *Drs. Diana Northup, Kathleen Lavoie, and H. Len Vacher retired from the Board in May of 2010, and the following were elected to fill those vacancies: Robert Brinkmann, Ph.D. (University of South Florida), David Kampwerth, (U.S. Fish and Wildlife), and Jesse Richardson (Virginia Tech).*

NCKRI STAFF

*Dr. George Veni,
Executive Director*



Dr. Veni is an internationally recognized cave and karst hydrogeologist. Prior to NCKRI, he owned and served as principal investigator of George Veni and Associates for more than 20 years. He has conducted extensive karst research throughout the United States and in several other countries. His administrative work includes serving as the Executive Secretary of the National Speleological Society's Section of Cave Geology and Geography for 11 years, President of the Texas Speleological Survey for 13 years, Adjunct Secretary of the Union Internationale de Spéléologie (UIS) from 2002-2009, and UIS Vice President of Administration since 2009. He has served as a committee member of geological, geographical, and biological dissertations at The University of Texas and Harokopio University (Greece), and teaches karst geosciences courses for Western Kentucky University. He has published and presented over 170 papers and five books, on hydrogeology, biology, and environmental management in karst.

*Dr. Penelope Boston,
Academic Program
Associate Director*



Photo courtesy of Val Hildreth-Werker

Dr. Boston teaches classes in cave and karst science, geomicrobiology, astrobiology, and global systems, and supervises graduate students studying those topics at New Mexico Tech. She received a National Research Council Postdoctoral Fellowship at NASA-Langley Research Center, has held positions at NCAR, the University of Colorado, University of New Mexico, and founded/operated her own non-profit research institute (Complex Systems Research Inc.) for 14 years before joining NCKRI in 2002. She is a Fellow of the NASA Institute for Advanced Concepts, Past President of the Association of Mars Explorers, Senior Editor of *Astrobiology*, member of the NASA Advisory Council Committee on Planetary Protection, member of the National Academy of Sciences COMPLEX committee, and past advisory board member for the *Journal of Cave & Karst Studies*.

*Dianne Gillespie,
Associate Director of Education*

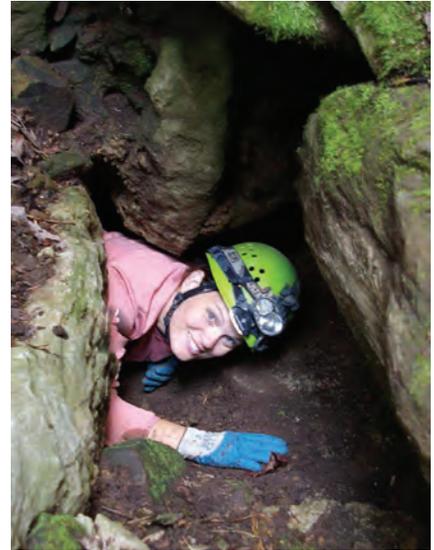


Photo courtesy of Jerry Fant

Ms. Gillespie began working for NCKRI in June 2009 and brings with her a wealth of teaching experience, both formal and informal. While most of this experience has been gained in Kentucky and Tennessee classrooms, she has also conducted and assisted with cave and karst education programs with the National Park Service, American Cave Conservation Association, and Western Kentucky University, among others. Ms. Gillespie holds a Masters degree in education, with a focus on science and history, and is the Education Division Chief of the National Speleological Society. She is an active and experienced cave explorer and surveyor.

Ms Gillespie brings a diverse and creative set of talents to NCKRI, with a Bachelors degree in theatre, and through a decade of theatrical and television production experiences with Kentucky Educational Television, the state of Florida, Discovery Channel, and more. She serves on education and cave and karst management committees for Carlsbad Municipal Schools and the U.S. Forest Service.

*Dr. Lewis A. Land,
Karst Hydrologist*



Dr. Land is a karst hydrogeologist with the New Mexico Bureau of Geology and Mineral Resources (NMBGMR), and serves as the Bureau's liaison with NCKRI. Prior to his career as a hydrogeologist, Dr. Land spent eight years in the petroleum industry exploring for new oil reserves in the Mid-Continent and Rocky Mountain regions of the U.S., and offshore West Africa. He received his Ph.D. from the University of North Carolina-Chapel Hill, where his doctoral research included submersible investigations of submarine sinkholes in the Straits of Florida. Before coming to work for NCKRI and NMBGMR in 2002, Dr. Land spent two years with the North Carolina Division of Water Resources conducting geophysical surveys of aquifers beneath the coastal plain of North Carolina.

Dr. Land's current research focuses on regional investigations of karstic aquifers and associated phenomena in southern New Mexico. He has served on several graduate student committees at New Mexico Tech (NMT), and is an adjunct faculty member in the NMT Department of Earth and Environmental Sciences. He is a Past-President of the New Mexico Geological Society (NMGS), and served for five years on the NMGS Executive Committee.

*Lisa Majkowski,
Cave & Karst Studies
Program Liaison*



Lisa works for the New Mexico Tech Earth and Environmental Science Department as the Earth Systems Specialist, as well as being the Cave and Karst Studies Program Liaison with NCKRI. Lisa received her Bachelors and Masters of Science degrees in geology from New Mexico Tech. Focus areas included grant budget management, technical meeting development, proposal management, national conference exhibiting, scientific and technical reporting, and geographic information systems (GIS).

In addition to her role with NCKRI, Lisa is also the program manager for several other large projects including the CRONUS-Earth Project, the New Mexico-EPSCoR Undergraduate Research Opportunities Program (REU), the Chemistry Interdisciplinary Science for the Environment REU Program, and the NASA instrument project: New Mexico Exoplanet Spectrographic Survey Instrument.

During the summer of 2009, Lisa conducted fieldwork with Dr. Fred Phillips of NMT to model the neotectonic evolution of the Owens Valley in California. She also worked on an REU project which focused on using GIS techniques to understand the spatial distribution and temporal changes of the Mora Valley, New Mexico, acequia (irrigation canal) system.

*Debbie Herr,
Administrative Coordinator*



Debbie joined NCKRI in January 2008 to organize and lead its administrative activities after working as a secretary in the Truth or Consequences Municipal School District for 11½ years. She received an Associate's Degree in Secretarial Administration from New Mexico State University at Carlsbad, and has over 20 years experience as a secretary and administrative assistant. Debbie is also a piano accompanist, having worked with many high school students, several churches, a community chorus, and many soloists, both vocal and instrumental.

Debbie has taken on the task of purchasing new furniture and equipment for NCKRI, as well as ensuring all NCKRI inventory is up-to-date.

Continuing Education

NCKRI staff continue to expand their skills whenever possible. Formal training attended by one or more staff members in the past year include:

- A two-day cave photography workshop taught by Peter Jones.
- Bat conservation, survey, and management workshop by Bat Conservation International and the U.S. Forest Service, in Carlsbad, New Mexico.
- Training in Austin, Texas, on new electrical resistivity equipment.
- Training in Albuquerque, New Mexico, on new GPS equipment.

STAFF PUBLICATIONS

Refereed

Journal Papers

Boston, P., Todd, P., van de Kamp, J.L., Northup, D., and Spilde, M. 2009. Mars simulation challenge experiments: Microorganisms from natural rock and cave communities. In *Gravity Space Biology* 22(2):39-43.

Johnson, S., Schindel, G. and Veni, G. 2010. Tracing groundwater flowpaths in the Edwards Aquifer Recharge Zone, Panther Springs Creek Basin, northern Bexar County, Texas. In *Report No. 10-01*, Edwards Aquifer Authority, 112.

Land, L. and Huff, G.F. 2010. Multi-tracer investigation of groundwater residence time in a karstic aquifer: Bitter Lakes National Wildlife Refuge, New Mexico, USA: In *Hydrogeology Journal*, 18: 455-472.

Melim, L.A., Liesheidt, R., Northup, D.E., Spilde, M.N., Boston, P. and Queen, J.M. 2009. A biosignature suite from cave pool precipitates, Cottonwood Cave, New Mexico. In *Astrobiology*, 9(9):907-917.

Northup, D.E., Snider, J.R., Spilde, M.N., Porter, M.L., van de Kamp, J.L., Boston, P.J., and Nyberg, A.M. 2010. Diversity of rock varnish bacterial communities from Black Canyon, New Mexico. J. In *Geophysics Research – Biogeoscience*, 115:G02007.

Strader, B., Schubert, K., Quintana, M., Gomez, E., Curnutt, J., and Boston, P. 2010. Estimation, modeling, and simulation of patterned growth in extreme environments. In, *Software Tools and Algorithms for Biological Systems*, 550.

Conference Proceedings Papers

Froehlich, D., Froehlich, L., Toomey, R.S. and Veni, G. 2009. Late Pleistocene to Historic vertebrate fauna from caves and karst features at Camp Bullis, Texas. In *Proceedings of the 15th International Congress of Speleology*, Kerrville, Texas, 80-85

Golubović Deligianni, M., Pavlopoulos, K., Veni, G. and Parcharidis, I. 2009. Geomorphological evolution and digital mapping of the Ksiromero Region, western Greece. In *Proceedings of the 15th International Congress of Speleology*, Kerrville, Texas, 1458-1462.

Johnson, S., Schindel, G. and Veni, G. 2009. Tracing groundwater flowpaths in the Edwards Aquifer Recharge Zone, Panther Springs Creek Basin, northern Bexar County, Texas USA. In *Proceedings of the 15th International Congress of Speleology*, Kerrville, Texas, 538.

Krejca, J.K., Reddell, J.R. and Veni, G. 2009. The cave fauna of Texas. In *Proceedings of the 15th International Congress of Speleology*, Kerrville, Texas, 290.

Kuhlman, K.R., Behar, A.E., Jones, J., Boston, P.J., Antol, J., Hajos, G., Kelliher, W., Coleman, M., Crawford, R., Rothschild, L.,

Buehler, M., Bearman, G., and Wilson, D. 2010. Tumbleweed: A new paradigm for surveying Mars for in-situ resources. In *Earth and Space 2010*, 209-215.

Land, L. 2009. Anthropogenic sinkholes in the Delaware Basin region of west Texas and southeastern New Mexico, USA. In *Proceedings of the 15th International Congress of Speleology*, Kerrville, Texas, 1575-1580.

Schubert, K.E., Gomez, E., Curnutt, J. and Boston, P. 2010. To live and die in CA. In *Proceedings of the 2010 International Conference on Bioinformatics and Computational Biology*, 498.

Spilde, M.N., Kooser, A., Boston, P.J., and Northup, D.E. 2009. Speleosol: A subterranean soil. In *Proceedings of the 15th International Congress of Speleology*, Kerrville, Texas, 338-344.

Veni, G. 2009. Karst landscape evolution: impacts on speciation, biogeography, and protection of rare and endangered species. In *Proceedings of the 15th International Congress of Speleology*, Kerrville, Texas, 771-776.

Veni, G., 2009. National and international partnership building for speleology: the U.S. National Cave and Karst Research Institute. In *Proceedings of the 15th International Congress of Speleology*, Kerrville, Texas, 2044-2047.

Veni, George, Poulianos, N.A., Golubović Deligianni, M. and Poulianos, A.N. 2009. Preliminary hydrogeologic survey of Petralona Cave, Chalkidiki, Greece. In *Proceedings of the 15th International Congress of Speleology*, Kerrville, Texas 1717-1722.



Book Chapters

Boston, P.J., Summers-Engel, A., Barton, H.A., Northup, D.E., Curry, M.C., and Spilde, M.N., "Geomicrobiology of Caves," in *Caves and Karst of the USA*, A.N. Palmer and M.V. Palmer, eds., (Huntsville, AL: National Speleological Society Press, 2009), 403-410.

Veni, George, "The Great Plains," in *Caves and Karst of the United States*, A.N. Palmer and M.V. Palmer eds. (Huntsville, AL: National Speleological Society, 2009), 200-210.

Veni, G. and A.N. Palmer, "Eastern Kansas and Oklahoma," in *Caves and Karst of the United States*, A.N. Palmer and M.V. Palmer eds. (Huntsville, AL: National Speleological Society, 2009), 180.



Photo by George Veni

Groundwater seepage stains the walls of Satan Canyon Shelter, Val Verde County, Texas. Pecos Style rock art in this and other shelters in the area is otherwise protected from erosion and dates from 5,000-6,000 years old.

Unrefereed Papers

Boston, P. 2010. Biopatterning in Cave Carbonates and Microbial Mats. *NASA Computational Astrobiology Summer School*, Honolulu, HI.

Boston, P.J. 2009. Extraterrestrial lavatubes: Repositories of science resources and human exploration. *Geological Society of America Annual Conference*. Portland, OR.

Boston, P. 2010. Snowy River: Walking hand in hand with beauty and science. *Decade of Discovery: National Landscape Conservancy System Symposium*. Bureau of Land Management, Albuquerque, NM.

Boston, P.J., Spilde, M.N., and Northup, D.E. 2010. Lavatubes as repositories for life, biosignatures, and telltale geochemistries. *Astrobiology Science Conference* Houston, TX.

Boston, P.J., Spilde, M.N., and Northup, D.E. 2009. The geomicrobial life of lavatubes: Biosignatures on Earth and beyond. *Geological Society of America Annual Conference*. Portland, OR.

Boston, P.J., Spilde, M.N., Northup, D.E., Curry, M.D., Melim, L.A., and Rosales-Lagarde, L. 2010. Seekers of life below the surface of Mars. *Astrobiology Science Conference* Houston, TX.

Chanover, N.J., Glenar, D. Voelz, D., Xiao, X., Tawalbeh, R., Boston, P., Brinckerhoff, W., Mahaffy, P., and Getty, S. 2010. An AOTF-LDTOF Spectrometer Suite for In Situ Organic Detection and Characterization. *Astrobiology Science Conference*. Houston, TX.

Land, L., 2009. World's longest speleothem: New results from radiometric dating and hydrologic observations. *Geological Society of America Annual Conference*. Portland, OR.

Land, L. & Huff, G.F. 2010. Multi-tracer investigation of groundwater

residence time in a karstic aquifer: Bitter Lakes National Wildlife Refuge, New Mexico, USA: In *New Mexico Bureau of Geology and Mineral Resources Open-File Report 521*: 32.

Melim, L.A., Spilde, M.N., Northup, D.E. and Boston, P.J. 2010. Biosignatures in Pleistocene cave pool speleothems. *Astrobiology Science Conference*, Houston, TX.

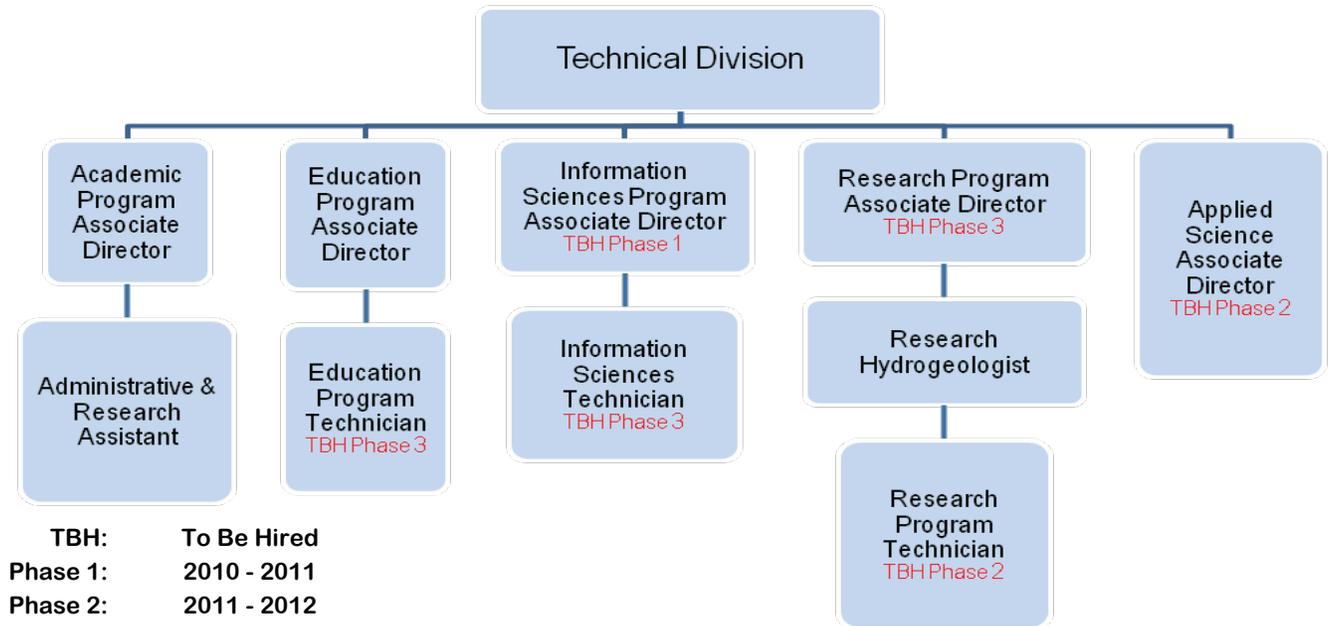
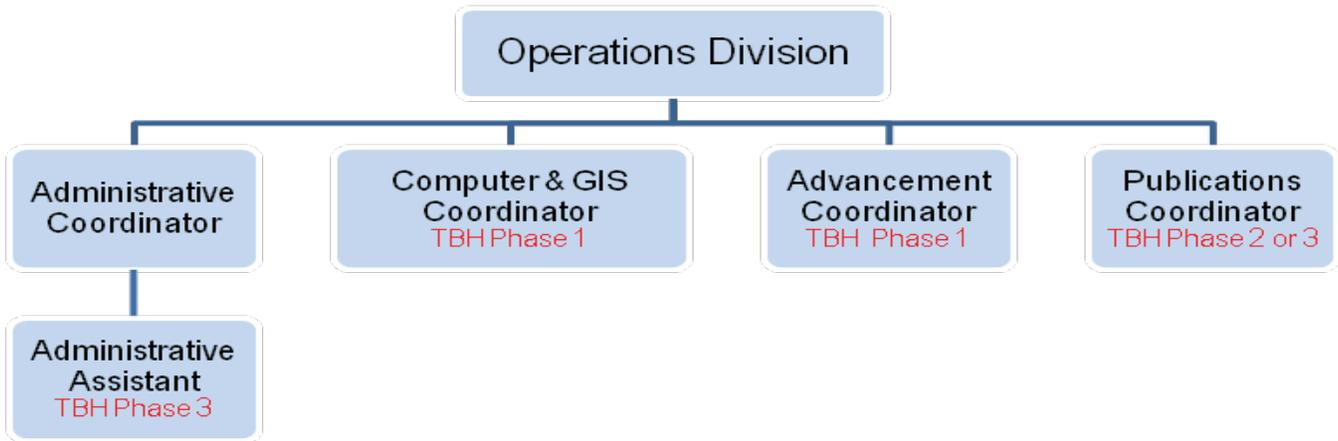
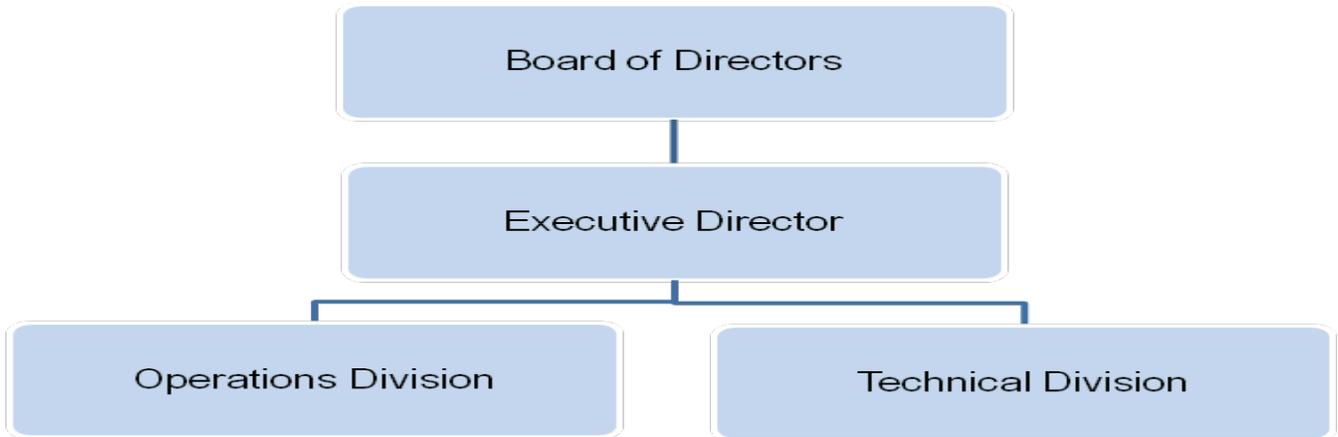
Spilde, M.N., Kooser, A., Northup, D.E., Boston, P.J., and Provencio, P. 2010. Mineralogical studies in Snowy River Passage, Fort Stanton Cave, New Mexico. *Decade of Discovery: National Landscape Conservancy System Symposium*. Bureau of Land Management, Albuquerque, NM.



Photo by George Veni

Solutionally enlarged fractures stripe the surface above Petralona Cave, Greece.

ORGANIZATIONAL STRUCTURE

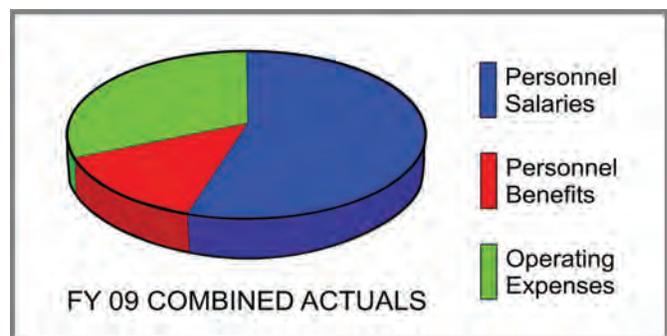
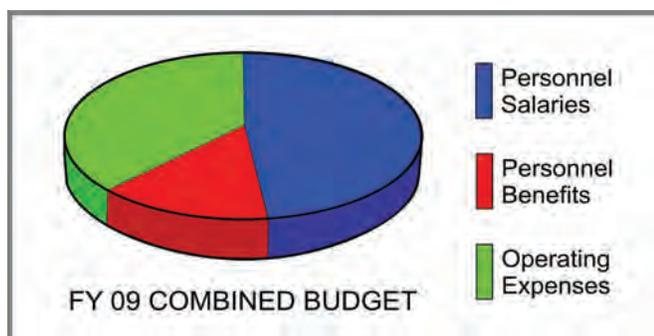


TBH: To Be Hired
Phase 1: 2010 - 2011
Phase 2: 2011 - 2012
Phase 3: 2012 - 2013

(all hiring periods and positions dependent on available funding and needs)

2009-2010 BUDGET

	National Park Service		State of New Mexico		COMBINED	
	FY09 Budget	FY09 Actuals	FY09 Budget	FY09 Actuals	FY 09 Combined Budget	FY 09 Combined Actuals
REVENUE						
State General Funds Appropriation			465,100	465,100	465,100	465,100
Federal Fund Appropriation	323,000	323,000			323,000	323,000
Fund Balance (Carryforward)	0		635,067	635,067	635,067	635,067
TOTAL REVENUE	323,000	323,000	1,100,167	1,100,167	1,423,167	1,423,167
EXPENSES						
Staff	185,049	171,916	158,368	146,837	343,417	318,753
Students			35,000	6,480	35,000	6,480
Project Salaries Sub-total	185,049	171,916	193,368	153,317	378,417	325,233
FRINGE BENEFITS						
Staff	59,216	60,346	50,678	48,374	109,894	108,720
Students			700	130	700	130
Fringe Benefits Sub-total	59,216	60,346	51,378	48,504	110,594	108,850
TOTAL PERSONNEL EXPENSES	244,265	232,262	244,746	201,821	489,011	434,083
OPERATING EXPENSES						
Rent, Utilities, Telephone		57	18,000	33,199	18,000	33,256
Supplies & Expenses		26,155	32,820	24,781	32,820	50,936
Facility Fixtures				25,439		25,439
Travel	14,655	15,368	39,500	19,317	54,155	34,685
Contractor Services		3,945				3,945
Property & Equipment		2,902	93,397	145,727	93,397	148,629
Programs	20,000	152	11,723	-150	31,723	2
NMT Administrative Support			24,914	20,000	24,914	20,000
NMT "Indirect" from NPS Budget (8%)	24,080	21,642			24,080	21,642
NPS "Indirect" to GRD at 6% on NPS Appropriation	20,000	20,000			20,000	20,000
TOTAL OPERATING EXPENSE	78,735	90,221	220,354	268,313	299,089	358,534
TOTAL ALL EXPENSES	323,000	322,483	465,100	470,134	788,100	792,617





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