

January 2008

National Cave and Karst Research Institute 2008-2009 Annual Report

National Cave and Karst Research Institute

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2008-2009
ANNUAL REPORT

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Cover Photo

Manjang Cave, Jeju Island, Republic of Korea. This 13.4-km-long lava tube is the longest in Korea and part of the Jeju Island World Heritage Site. NCKRI is studying volcanic caves around the world as likely analogs for extraterrestrial caves and potential sites of microbial life.

Inside Cover Photo

"Bacon" is one of many varieties of mineral deposits that occur in caves. This beautiful example is from Cave Without A Name, a show cave in Texas. In addition to their aesthetic qualities, these deposits often hold key information useful to interpreting the origin of a cave or the paleoclimatic and environmental conditions of a region. NCKRI conducts and supports careful scientific research of cave minerals.

Back Cover Photo

One of many entrances into the Candelaria Cave System in Guatemala. Like many caves in the Maya area, this cave contains important archeological materials. NCKRI sees cave archeology is an important but poorly supported field of study, and plans to develop programs to bolster such research in the US and abroad.

Photos by George Veni.





EXECUTIVE DIRECTOR'S REPORT

July 2008 through June 2009 will prove to be a pivotal year in the history of the National Cave and Karst Research Institute (NCKRI). Congress created NCKRI to conduct, support, facilitate, and promote programs in cave and karst research, education, environmental management, and data acquisition and sharing. NCKRI's efforts in these areas were limited due to three main issues, all of which were resolved or alleviated this year: headquarters construction, funding, and staff. This annual report covers NCKRI's diverse array of projects and activities during the last 12 months, but below are details on these three items and a look toward the future.

Headquarters Construction: Groundbreaking for the construction for NCKRI Headquarters officially occurred on November 24, 2008. To fully meet its congressional mandates, NCKRI needs a specially designed building to conduct its programs. The 17,315 ft² building will contain a bookstore, museum/exhibit hall, classrooms, laboratory, library, offices, and meeting space. NCKRI Headquarters will also be highly energy efficient and have innovative design features, some of which will serve nationally as models for green building techniques that can be used in karst areas to prevent or minimize adverse environmental impacts.

Funding: The legislation creating NCKRI in 1998 contained one well-intentioned clause, that all federal funds must be matched by non-federal funds, but it caused unforeseen problems. Throughout NCKRI's history, federal agencies and federally-funded organizations have had the greatest interest in working with NCKRI, but non-federal matches either didn't exist or could not be located in the available time. On March 30, 2009, President Barack Obama signed a bill that removed the matching funds requirement. The bill was written and sponsored by New Mexico Senator Jeff Bingaman. NCKRI is now able to compete fairly for construction, research, education, and other federal funds on a level playing field with other organizations.

Staff: NCKRI currently has few employees and any addition is important, but few will be as vital as the Education Director who was hired nearly at the end of this reporting year on June 22, 2009. Education is much more than teaching kids from grades K-12. Dianne Gillespie will develop a comprehensive outreach program that nationally and later internationally will encompass all ages and demographics through NCKRI's website, museum, bookstore, and a traveling series of lectures, workshops, and meetings. She will begin her tenure with a nationwide tour of cave, karst, science, and environmental science museums, research institutes, and university programs to develop ideas from which to build NCKRI's education program and museum while establishing partnerships to enhance cave and karst education in the US and abroad.

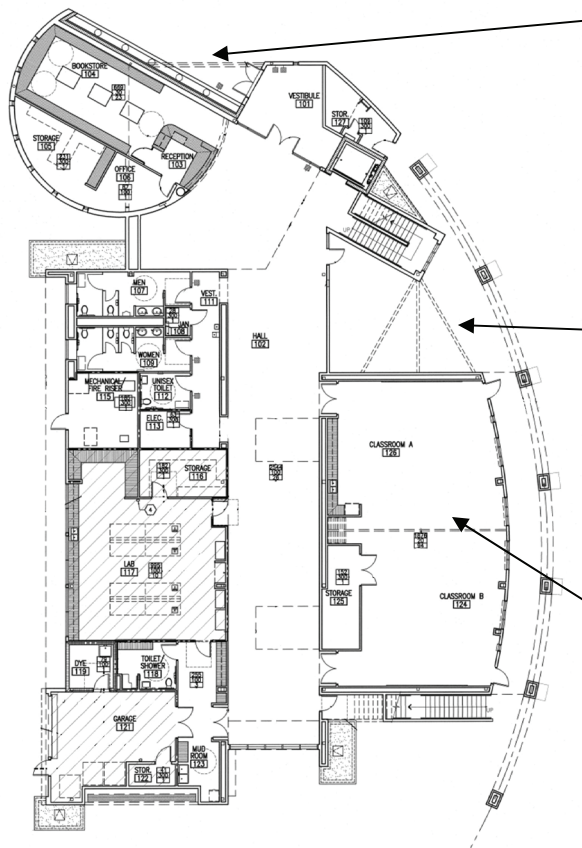
Clearly, NCKRI has a lot of work ahead to meet its ambitious goals. This year's accomplishments were important steps toward meeting them. However, the key to NCKRI's success lies with the continued and unflagging support of its many friends and partners. I thank them all.

George Veni, Ph.D.

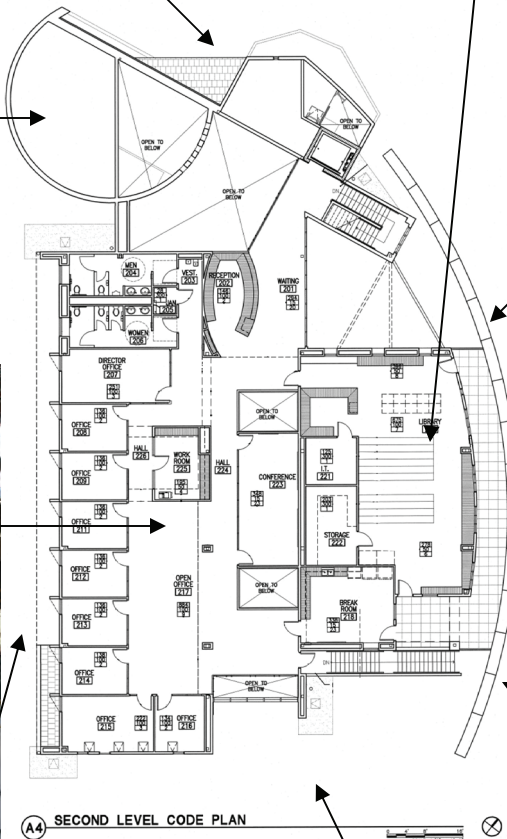
NCKRI HEADQUARTERS CONSTRUCTION

On Monday, November 24, 2008, NCKRI broke ground for its headquarters building in Carlsbad, New Mexico. Several state and local officials and over 90 other guests attended from throughout the region. The building's exterior and part of the interior will be complete by November 2009. Construction was started to prevent inflation of most of the building's costs while NCKRI and its partners seek funds to complete the remaining portions of the interior.

L to R: Hazel Medville, NCKRI Board President; Dr. Daniel Lopez, New Mexico Tech President; New Mexico State Representative John Heaton; Carlsbad Mayor Bob Forrest; Carol McCoy, National Park Service Representative to NCKRI Board; Lynn Ditto, Representative for US Senator Jeff Bingaman; Dr. George Veni, NCKRI Executive Director.



A2 FIRST LEVEL CODE PLAN



NCKRI PROJECTS

Anthropogenic Sinkholes in the Delaware Basin Region of West Texas and Southeastern New Mexico

Sinkholes within gypsum bed-rock in the Delaware Basin of west Texas and southeastern New Mexico are seldom of human origin, but those few are highly significant. These anthropogenic sinkholes are often associated with improperly cased abandoned oil wells or solution mining of salt beds below the gypsum. On July 16th, 2008 a sinkhole formed abruptly at the site of a brine well in Eddy County, New Mexico, about 17 km southwest of the small community of Loco Hills (see photo to the right).

The well operator was injecting fresh water into salt beds of the Permian Salado Formation and pumping out the resulting brine for use as oil field drilling fluid. Borehole problems had prevented the operator from conducting required downhole sonar surveys to assess the dimensions of sub-



Photo by George Veni

Jim's Water Service Well Sinkhole on July 20, 2008, four days after the initial collapse.

surface void space. The resulting sinkhole, referred to as Jim's Water

Service Well Sinkhole, formed in just a few hours by catastrophic collapse of overlying mudstone and gypsum, and in less than one month reached a diameter of 111 m and a depth of ~64 m (see photo to the left). Luckily, a seismograph had been deployed 13.9 km southeast of the brine well a few months earlier, and collapse in the subsurface was captured on the seismograph record a few hours before the cavity breached the surface (see top of next page). This may be the first documented seismologic record of catastrophic sinkhole formation.

On November 3, 2008, a new sinkhole, Loco Hills Sinkhole, formed within the city limits of Loco Hills, ~17 km northeast of Jim's Water Service Well Sinkhole. Loco Hills Sinkhole was also associated with a brine well that was shut in three months earlier after it failed a mechanical integrity test, part of a state-wide review ordered by the New Mexico Oil Conservation Division (NMOCD) of regulations covering all

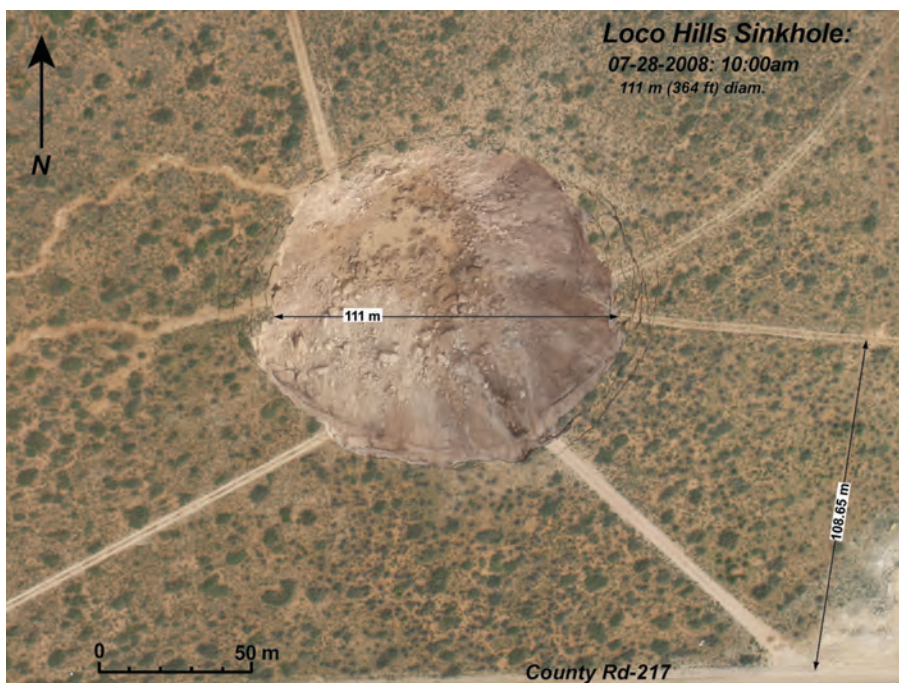
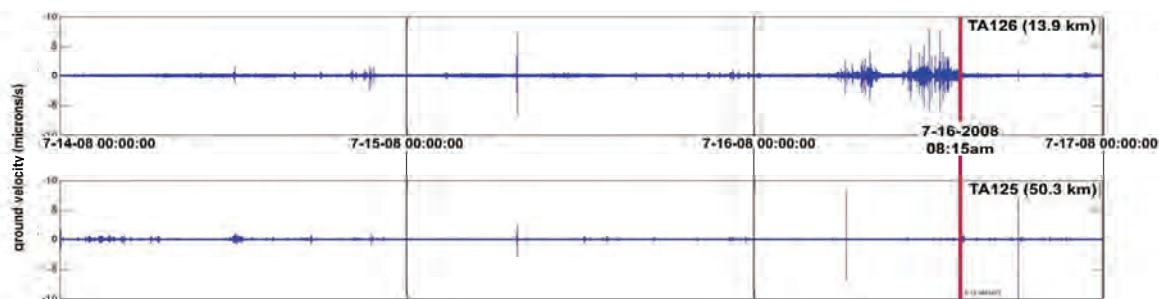


Photo by Lewis Land

Jim's Water Service Sinkhole, July 28, 2008, after sides began to slump and water drained back into the subsurface.



Seismograph TA126-A 3-day record of vertical ground velocity, located 13.9 km southeast of Jim's Water Well Service Sinkhole, shows more than 6 hours of ground motion from subsurface collapse of the brine well cavity. Time of surface breaching (8:15am) is indicated by the vertical red line.

brine wells across the state after the first sinkhole collapsed.

A spokesperson for NMOCD noted that of New Mexico's 34 brine well facilities, two have collapsed for a failure rate of 6%. However, if only shallow brine wells are considered, with depth to the bottom of casing less than 150 m (500 ft), there are only five such facilities, of which two have collapsed, for a failure rate of 40%. One of the remaining three wells is within Carlsbad city limits; its owners voluntarily abandoned operations soon after the collapse of Jim's Water Service Well Sinkhole.

Anthropogenic sinkholes are a serious problem in the oil fields of southeastern New Mexico and west Texas. The National Cave and Karst Research Institute has been actively involved in observing and reporting recent sinkhole phenomena in cooperation with NMOCD and the State Land Office. Three NCKRI-authored papers have been published on the subject. We anticipate expanding our investigations of anthropogenic karst features in the next fiscal year with targeted geophysical surveys and satellite data.

Fort Stanton Cave

For the past six years Dr. Lewis Land has participated in investigations of the geology and hydrology of the Snowy River Formation in Fort Stanton Cave (FSC) in the northern Sacramento Mountains of New Mexico. The Snowy River Formation is a cave pool deposit that extends for more than 7 km in a passage discovered in FSC in 2001, and has been

described as perhaps the longest cave deposit on earth (see photo below).

In June 2008, the U.S. Bureau of Land Management (BLM) awarded funds to New Mexico Tech (NMT) for a scientific assessment of Snowy River. The first year of concentrated research has focused on further age-dating of cores from the deposit, extensive mineralogical analysis, analysis of native geo-microbial populations, and beginning a human-associated microbial impact study.

The team consists of Dr. Penny Boston (NCKRI and NMT) as project director, Dr. Lewis Land (NCKRI and New Mexico Bureau of Geology and Mineral Resources) as hydrologist, and Dr. John Wilson (NMT) who will be conducting micrometeorological studies. Dr. Michael Spilde heads the University of New Mexico (UNM)

part of the team as mineralogist and manager of the Electron Microscope and Electron Microprobe laboratories. NCKRI board member Dr. Diana Northup is the UNM team's microbiologist, conducting molecular phylogenetic studies of native microorganisms and also heads the microbial human impact study, and Dr. Victor Polyak is conducting the dating analyses. Dr. Paula Provencio, Sandia Labs, is working on transmission electron microscopy of cave samples.

This comprehensive, integrated five-year study of Fort Stanton Cave hopes to produce a broad picture of the history and development of this unique system. This BLM land was designated by Congress as the first subsurface national conservation area, and signed into law by President Obama in March 2009.



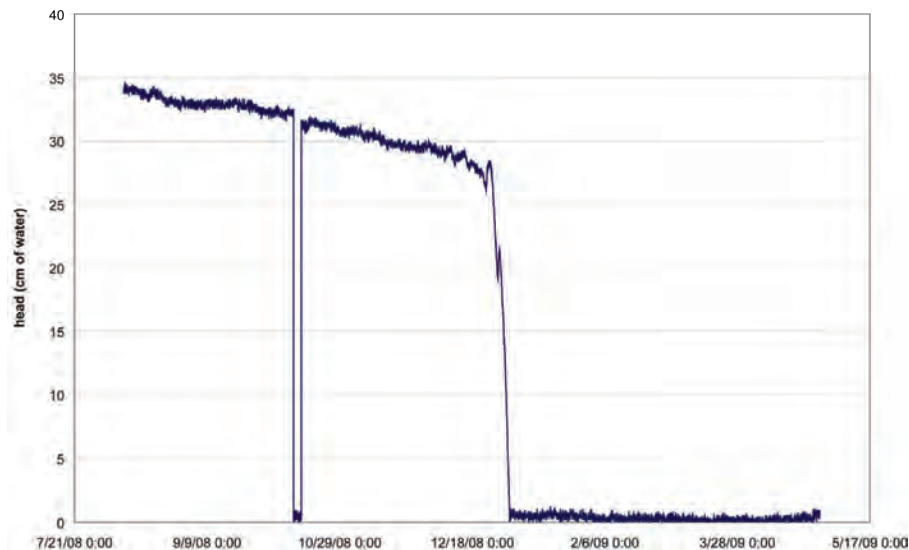
Photo by John R. Cochran
Snowy River pool deposit in Fort Stanton Cave. View to south (upstream).

Hydrologic Observations

The Snowy River passage periodically floods during the southwestern monsoon season in late summer and early fall. To develop a better understanding of the hydrology of the cave, in August 2008 a data logger was deployed at Mud Turtle Junction in the Snowy River passage. The data logger made hourly recordings of water levels and water temperature in the flooded Snowy River passage over a nine-month period (see graph to the right). The record shows a gradual decline in water levels in the passage from 34 to 27 cm between August 8 and December 25, 2008. Then, in the one-week period between December 25 and January 1, 2009, water levels declined to zero and remained there for the duration of the period of record.

The origin of water flow in the Snowy River passage has been the subject of considerable speculation since it was first observed in 2007. The presence of water may be an annual event, occurring shortly after the start of the mid-year monsoon season. Two types of potential sources for the water include: (1) diffuse flow into the passage associated with a rising water table, and (2) a point source of recharge via an upgradient sinkhole or losing stream. The sudden disappearance of water in the Snowy River passage during the last week of 2008 is more consistent with the latter hypothesis, since it seems unlikely that evaporation or the slow percolation of water into underlying sediment would occur so rapidly. Rather, the record would suggest that the water supply had been abruptly “turned off.” The broader implication of this hypothesis is the existence of a potential second entrance into the Snowy River section of Fort Stanton Cave, presumably somewhere farther to the south. Whether this possible second entrance would be enterable by humans can only be determined by further study and exploration.

A number of questions remain regarding the hydrologic setting of Fort Stanton Cave. However, given the present data and field observa-



Data logger record showing water level variation at Mud Turtle Junction in the Snowy River passage of Fort Stanton Cave. The three-day period of zero water level in mid-October probably represents an instrument malfunction.

tions, it appears increasingly likely that water flow and spring discharge in the Snowy River passage represents one component of a larger karstic aquifer system in the upper Rio Hondo Basin. Hydrologic studies will continue next year, with deployment of additional dataloggers and expanded investigations of the hydrology and paleohydrology of the cave.

Radiometric Dating of Cores

In 2008, we collected nine cores along an 884 m, south-north transect from the Snowy River pool deposit using a hand-held electric drill fitted with a water-cooled diamond bit. The cores are all 2.5 cm in diameter and range in length from 3.2 to 9 cm (see photo below). All but one of the cores penetrated the entire Snowy River



Core samples from Snowy River Formation, south-north transect.

Photo by Lewis Land

Formation. All of the cores display fine, sub-millimeter-scale lamination, evidently the result of discrete episodes of calcite deposition during times when the passage was flooded. Wet and dry episodes in the cave passage should reflect alternating periods of abundant rainfall and drought in the northern Sacramento Mountains. The cores thus have excellent potential for providing a record of the paleoclimatology and paleohydrology of the area. The basal layers of six of the cores were dated with U-Th techniques, yielding ages from 687 to 1,335 years BP, indicating an abrupt change in climatic or hydrochemical conditions within the past millennium. We anticipate collecting and dating additional cores, and developing a detailed record of the stable isotope composition of the Snowy River deposit.

Carbonate Pool Precipitates

This ongoing project, supported by the National Science Foundation, and led by NCKRI geomicrobiologist Dr. Penelope Boston, Dr. Leslie Melim (Western Illinois University), and NCKRI board member Dr. Diana Northup (University of New Mexico), studies the role of microbiological and geological processes in the creation of unique carbonate pool precipitates. Microbially-mediated carbonate precipitation is globally significant. It can provide a mechanism for understanding and potentially manipulating carbon sequestration for enhanced removal of climate-warming carbon from the atmosphere.

Caves in arid lands, as semi-closed systems stripped of the influence of surface weathering, provide a particularly valuable window into the world of carbonate-precipitating microorganisms. Carbon moves from the surface to the subsurface, where it is preserved in carbonate precipitates. These precipitates, many of which are biogenic, record microbial influences, surface climate, and ecosystem changes.

These investigations are identifying a suite of biosignatures for carbonate precipitates and are making

significant contributions to the identification of biosignatures in carbonate deposits. They are revealing microbial morphologies and other biosignatures present in secondary carbonate cave pool precipitates such as pool fingers, pendant forms that hang from cave walls and shelfstone in paleo- and modern pools. Preliminary scanning electron microscopy (SEM) shows microbial morphologies, such as the reticulated filaments, that appear to be consistently found in these pool precipitates (see example in the photo below).

Pool descriptions from fieldwork identify pool characteristics associated with the occurrence of more biogenic forms of pool precipitates. Shallow pools with still water are seen as more likely to have biothems and deeper pools, if they have biothems, usually have them in their upper 20-30 cm suggesting biogenic structures form in shallow pool conditions. By associating SEM results with pool morphologies, we can help guide studies for detecting life on other planets.

The subsurface biodiversity that

inhabits the highly variable environments of caves is a major natural treasure about which little is known. Federal agencies in the United States and other entities across the world are charged with protecting many of these important subterranean wilderness areas on the basis of very incomplete knowledge of their properties, especially biology. Further, an estimated 25-30% of the world's population derives its water supply from karst aquifers in which caves play a major role. The geochemistry and microbiology of the phreatic (below the water table) and vadose (above the water table) zones is of paramount importance to understanding and managing groundwater resources. The role of the subsurface as the recipient of organic nutrients that originate on the surface and its role in recycling those materials back to surface watersheds through aquifers is complex and poorly understood.

This project will help shed light on these processes and is the first study of the microbial community associated with cave pools in arid environments using culture-

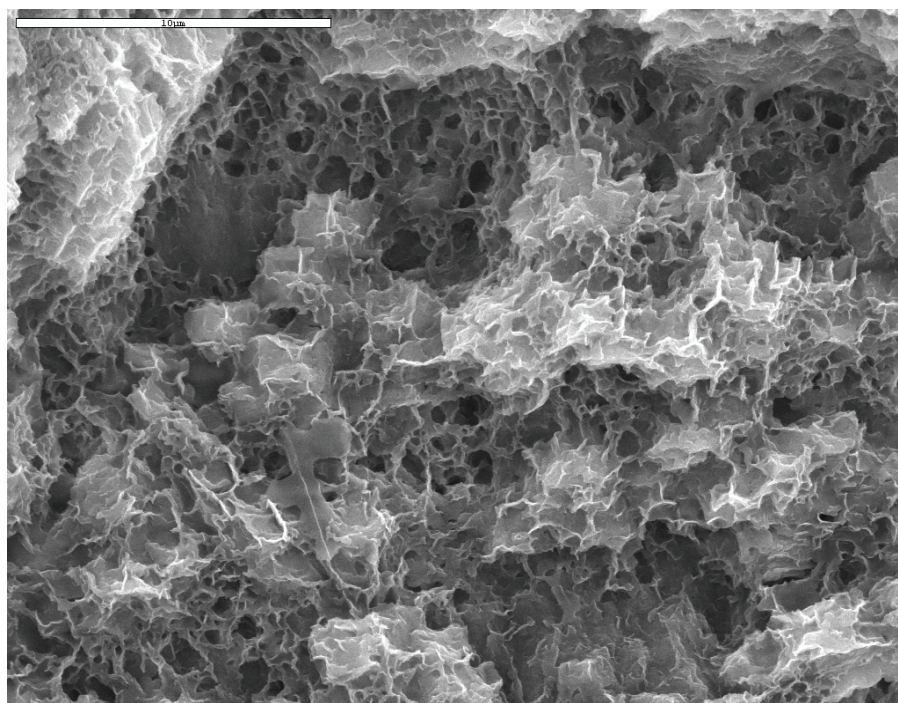


Photo by Michael Spilde, Diana Northup, and Leslie Melim
Scanning electron microscope image of possible meringue-style pool precipitate from Carlsbad Cavern, New Mexico, at 4,300x magnification.

independent techniques. The results from this year's studies show a diverse community of at least eight bacterial phyla, with a preponderance of Proteobacteria. Because of the depth of these pools below the land surface (~250 m) and their accessibility, these results will be of interest to those working in other subsurface aquatic environments.

Naica Mine Cave

A National Geographic documentary film, *Giant Crystal Cave*, began airing in October 2008. This documentary focuses on the work of Dr. Penelope Boston, her PhD student Laura Rosales-Lagarde, and other colleagues, in Cueva de los Cristales, the amazing and geothermally active cave in the Naica mine of Chihuahua, Mexico. Nests of up to 5-m long crystals crowding limestone cave rooms, crystalline iron oxide wall deposits, and a working temperature of 60°C, combined to make a unique and hazardous working environment. Italy's La Venta Caving Group and Dr. Paolo Forti from the University of



Photo by and modeled by Penelope Boston
Ice-packed suits and helmets, with refrigerated breathing air, allowed scientists to work for intervals of about 15-55 minutes in Cueva de los Cristales in Mexico's Naica Mine.

Bologna, provided vital collaboration with their ice suits (see photo in the lower left corner) and valuable scientific contributions.

Laboratory analysis of the fluid and solid inclusions continues at New Mexico Tech. Excitingly, 30 different cultures have been obtained from the crystal samples. These samples continue to grow slowly and are anticipated to produce enough material to begin analyses next year.

This documentary is the most watched National Geographic educational special to date. A different documentary, based on additional footage, was produced and broadcast by NHK of Japan in Spring 2009. Translations of this second special have appeared in a number of European markets.

Met Pro Corporation – Cave Microorganism Metabolic Capabilities

In a pilot effort, and in consultation with National Park Service solicitors, we have undertaken a screening program for microbial capabilities possibly possessed by some of our cave isolates and which interest our project sponsor, Met-Pro Corporation. Phase I provided an ideal proof-of-concept study for testing the new methods in place, enabling commercial utilization of natural biological resources present in our federal lands. Negotiations for Phase II are underway.

Iron-Manganese Deposits in Caves and Desert Varnish

This eight-year project studies the relationship between the types of metal-using microorganisms in a variety of caves and those that appear to contribute to surface rock coatings called "desert varnish." It is conducted by NCKRI's Dr. Penelope Boston at New Mexico Tech in collaboration with NCKRI board member and microbiologist Dr. Diana Northup and mineralogist Dr. Michael Spilde, both from the University of New Mexico, and other colleagues including many students from both institutions.

The project is funded by the National Science Foundation on several consecutive grants. Cave study sites include Lechuguilla Cave and Spider Cave in New Mexico, and Jewel Cave in South Dakota. Desert varnish study sites are in California, Colorado, New Mexico, Utah, and the Atacama Desert, Chile.

Imagery Data Extraction Collaborative

Scientific fields of study such as microbiology, astrobiology, and cave and karst sciences contain large collections of images and associated biological, physiochemical and geological datasets. The vast majority of these images are never shared nor examined by more than a handful of scientists. As interdisciplinary studies grow more common, the ability for scientists, students, teachers and interested citizens to collectively examine, analyze and annotate these images and data will grow in importance. In order to allow access to images and associated data, our team has created IDEC: Imagery Data Extraction Collaborative (<http://idec.aisti.org>).

The team consists of NCKRI board member Diana Northup, Jessica Snider, Johann van Reenen, Christy Crowley, Brian Freels-Stendel, and Jennifer Hathaway from the University of New Mexico (UNM), Lynn Collins, Mark Martinez, and James Powell from Los Alamos National Laboratory, and M. Alex Baker from the private sector.

IDEC consists of an integration of three open-source tools: Drupal, Gallery, and UNM DSpace. Drupal is an open-source content management system that has been rated best-in-class by the IBM Internet Technologies group. Gallery is an open-source image management system that can be integrated directly into Drupal. UNM DSpace is an open-source digital object repository platform (<https://repository.unm.edu/UNM/DSpace/handle/1928/526>) at UNM that houses the repository of available scanning electron microscopy images. A commenting function has been implemented in UNM DSpace to allow

viewers to provide their insights from viewing the images. All three tools are relatively easy to install and configure, and are widely used globally.

The team is using this configuration as a base for developing their broader collaborative workspaces for knowledge discovery with weblogs, forums, feeds, and image functionality enabled. Registered users of IDEC can scroll through photo albums of scanning electron microscope images designed around a central theme or question and can add their own conclusions or insights for each image. Users can participate in forums or blogs discussing topics such as current trends and questions in that area of science, and interesting discoveries and debates about interpretations of the data. Selected image galleries covering microbiology, microscopy and cave sciences are used to create lessons for high school and college level students. Finally, all recent relevant scientific articles, newspaper arti-

cles and government reports are displayed in the Feed Aggregator as well as links to other portal websites, allowing users to get the latest information on microscopy, geology, microbiology, astrobiology, speleology and geomicrobiology.

The team believes that this type of easy to use, virtual, collaborative research e-workspace will help answer questions with important implications in the study of caves, key features of karst terrains, and for the detection of life on other planets (astrobiology). The initial albums focus on the geomicrobiology of caves and karst.

Karst Information Portal

Data access, cataloguing, and evaluation challenge the progress of cave and karst research, education, and management. Crucial information is scattered throughout the mainstream journals and buried in gray literature, which includes maps, databases, techni-

cal reports, theses, dissertations, images, site and feature descriptions, and videos. The Karst Information Portal (KIP) is a solution to these research problems. KIP developed as an international partnership between NCKRI, the University of South Florida, the University of New Mexico, and the Union Internationale de Spéléologie to solve information access and management problems through an Internet gateway to karst data and services.

Like other well-known portals, KIP has grown as users and partners add databases, maps, gray literature, reports, and other information. Currently, over 5,000 resource items reside in the collection. KIP does not duplicate existing databases but serves to more efficiently access and process them. KIP has the potential to transform cave and karst studies by creating new knowledge through the integration of international information. Use of and interest in KIP have grown in the past year.



Example page of the DSpace karst and cave scanning electron microscopy image gallery with some annotated data.

Hypogene Karst

In October 2008, Dr. Lewis Land attended the Geological Society of America Annual Meeting in Houston, Texas, and co-chaired a topical session entitled “Hypogenic karst: Shedding light on once poorly understood hydrologic and morphologic features” with Geary Schindel, NCKRI board member from the Edwards Aquifer Authority. Fifteen speakers gave presentations, including three invited speakers: Drs. Alexander Klimchouk (National Academy of Sciences of Ukraine); Calvin Alexander (University of Minnesota); and Kevin Stafford (Stephen F. Austin University). Most of the authors subsequently submitted papers based on their presentations for publication in the *NCKRI Symposium 1: Advances in Hypogene Karst Studies*, edited by Drs. Kevin Stafford, Lewis Land and George Veni; Dr. Stafford is a recent former scholar of NCKRI’s academic program.

This book expands on the growing understanding of hypogenic karst systems with papers focused on examples in four countries and five US states. It also marks the first in a new NCKRI publication series.

Three of the volume’s papers on New Mexico, central Texas, and west Texas were authored or co-authored by NCKRI’s Drs. Land and Veni.



National Cave and Karst Research Institute Symposium 1: Advances in Hypogene Karst Studies.



Photo by George Veni

Hypogenic maze passages crossing at different levels in Robber Baron Cave, Texas.

Hypogene Karst Studies in Texas

The Texas-based paper in *Advances in Hypogene Karst Studies* is a new NCKRI-sponsored study conducted by Executive Director Dr. George Veni and Lynn Heizler of the New Mexico Bureau of Geology and Mineral Resources.

The Edwards Aquifer is an international well known karst aquifer formed within the Edwards Limestone in the Balcones Fault Zone. Caves and karst features in its recharge zone are epigenic, formed by water descending into the aquifer. However, the down-faulted sections are artesian, with hypogenic features formed by water rising from the aquifer.

Robber Baron Cave is formed within the Upper Cretaceous Austin Chalk in northern San Antonio. The cave exhibits features that demonstrate a hypogenic origin, including a 1.51-km-long network maze pattern, fissure-floored passages, passage ceilings laterally enlarged adjacent to a contact with an upper confining unit, and sediments produced by the dissolution of the host rock.

The Edwards Aquifer, which is

below the Austin Chalk and long considered hydrologically separated by impermeable units, provides the only source of water that could create the conditions necessary to form Robber Baron Cave. Hypogenic flow is currently observed where Edwards water rises along faults through the Austin and flows from the nearby San Antonio and San Pedro Park Springs. Anecdotal reports from the early 20th century describe pools and flowing streams in sections of Robber Baron Cave that are no longer accessible, where the water could have similarly risen from the Edwards along other faults.

The Edwards Aquifer enlarged eastward by stream incision along the Balcones Fault Zone, exposing down-faulted permeable units to allow groundwater discharge from lower elevation locations. Stream incision rates indicate that the hypogenic conditions necessary to form Robber Baron Cave occurred 2.0 to 2.5 million years ago, and thus set a minimum age for when the Bexar County area was added to the aquifer.

The presence of Robber Baron and other hypogenic caves and artesian springs in the Austin Chalk dem-

onstrate areas of significant localized upward flow into the Austin and from the paleo land surface. Veni and Heizler suggest that identification of these areas is important for establishing areas of more stringent land use regulations to prevent aquifer degradation through these highly permeable features situated outside of the presently recognized boundaries of the aquifer's recharge zone.

Microbes, the Moon, Mars, and Beyond: NASA Spaceward Bound Teacher Training

A total of eight expeditions for the NASA Spaceward Bound Teacher Training Program have occurred since 2006 in an ongoing partnership with NASA Ames Research Center to provide extreme environment field science experiences for K-12 educators. During the past fiscal year, expeditions were fielded to Canada, Australia, and the Mojave Desert and Mount Shasta in California. Dr. Penelope Boston is the team leader for cave, karst, lava tube, and microbiology activities. The March 2009 Mojave

Desert trip served 25 student teachers and Spaceward Bound alumni and approximately 20 scientists. The Australia expedition served 15 teachers and 12 scientists from all over Australia and the United States. Future expeditions are planned for the Mojave Desert in March 2010 and 1011, and to the Namibian Desert in 2010.

In 2009, subprojects continued on materials from Hawaii, the Azores, Mexico, and Oregon. The primary research focus was characterization of the microbial communities present and the roles they may be playing in secondary mineral deposits in lava tubes. In addition, following on NASA-funded projects from 2001 through 2006, with partners at Massachusetts Institute of Technology and TechShot, Inc., work continues on the role of extraterrestrial lava tubes on the Moon and Mars in future space exploration.

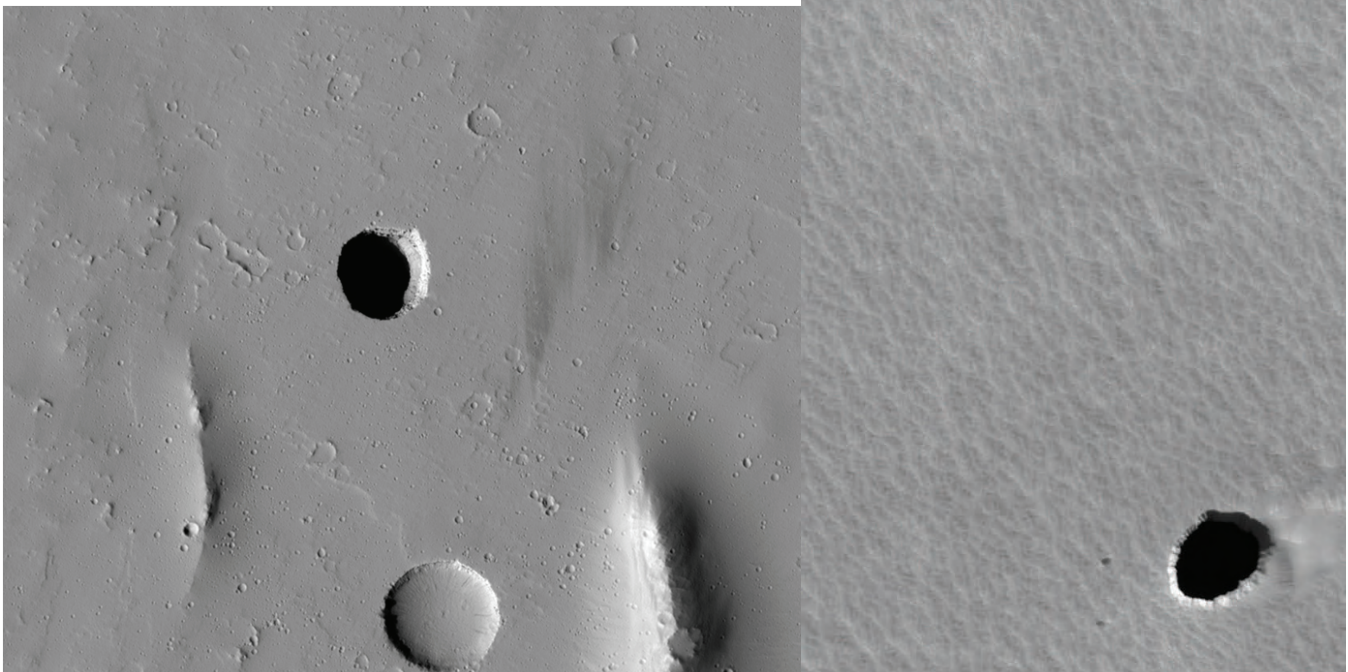
Work continues at a rapid pace on a NASA-funded project to develop and field-test a point spectrometer based on acousto-optic tunable filter technology to detect biologi-

cal signatures in samples collected during planetary missions to Mars, icy moons, or asteroids. Testing of the instrument is anticipated in late Spring 2010.

Work continues on mathematical modeling, funded by NASA Ames Research Center, using cellular automata techniques in an attempt to reproduce unusual microbial patterns that are seen in a number of caves. These "biovermiculations" appear to be a combination of biological and physical processes. In addition to the modeling, the team is designing long term monitoring experiments on living cave mats to study the effects of changing environmental parameters to mat development. Non-NCKRI team members include Dr. Keith Schubert and Dr. Ernesto Gomez (California State University, San Bernardino), Dr. Henry Sun (Desert Research Institute, Las Vegas), and Dr. Chris McKay (NASA Ames Research Center).

Pit craters near Tractus Fossae on Mars, and other cavernous features found on the planet by high resolution imaging, are potential high-priority sites for human exploration and the search for extraterrestrial microbial life.

Photos courtesy of NASA and the University of Arizona



STUDENT ACTIVITIES

Cave and Karst Studies Courses 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, including:

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

Dr. Boston currently supervises one Ph.D. student, three Master's students, one undergraduate senior thesis, and four independent study projects. Megan Curry successfully defended her Master's thesis in June 2009.

During the 2008-2009 year, the researchers and students of the Cave and Karst Studies Program have engaged in excellent and exciting research. The program has surpassed last year's record number of new and ongoing projects. With extensive grant submission activities and management supported by Lisa Ma-

jkowski and laboratory supervision by Dr. Rasima Bakhtiyarova, the program has set the standard at New Mexico Tech. Following are ongoing student-lead projects.

Snowy River, Fort Stanton Cave, New Mexico

NCKRI's Cave and Karst Studies Program has facilitated a NMT Senior Civil Engineering Design Class project, which created a working design for an entry shaft and security bunker for the proposed drilled route to the Snowy River passage in Fort Stanton Cave. The shaft will make future research easier, and possible in many cases, in addition to improving safety and preserving microclimatological and biological conditions in that unique section of the cave.

Origin of Moonmilk

Master's student Megan Curry competed her work on this long-term project and successfully defended her Masters thesis, *A Geomicrobiological and Geochemical Approach to the Biogenicity of Moonmilk Formation: Spider Cave and Pahoe Cave, NM; Thursday Morning Cave, CO; Thrush Cave and Cataract Cave, AK* in June 2009. The research, under the supervision of Dr. Penelope Boston, in collaboration with NCKRI board member Dr. Diana Northup of the University of New Mexico and colleagues from several other institutions, focused on the origin of pasty mineral deposits known, collectively as "moonmilk." Ms. Curry sampled moonmilk in a variety of caves from limestone karst to lava tubes, with

field sites in Alaska, California, Colorado, and New Mexico.

Evidence for biological, geochemical, and physical processes have all been found by different investigators. We are trying to discover how these formations depend on those different processes and if environmental conditions such as moisture, organic nutrients, temperature, or underlying bedrock type affect the development or type of moonmilk produced.

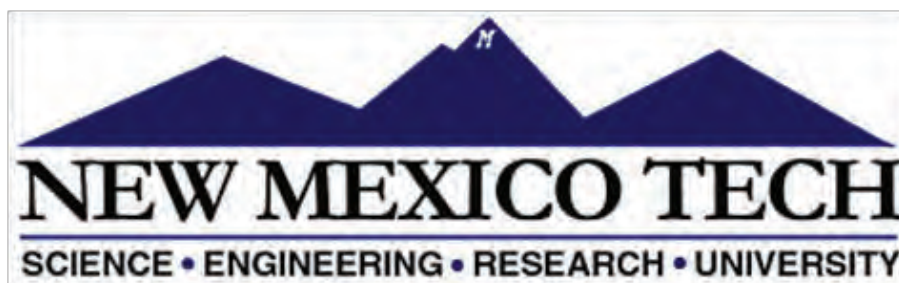
Sulfuric Acid Caves and Sulfur Springs of Tabasco, Mexico

Ph.D. student Laura Rosales-Lagarde continues her research, working to determine the geomicrobiological, mineralogical, and geological aspects of Cueva de Villa Luz and other sulfur caves and springs in the region of southern Tabasco, Mexico. This long-running project (1998-present) is focused on the origins of the hydrogen sulfide and other gases and waters flowing into those caves. Dr. Penelope Boston and colleagues from the University of New Mexico are studying the geomicrobiology of these systems. Ms. Rosales-Lagarde anticipates completion of her dissertation in fall 2009.

Additionally, Ms. Rosales-Lagarde leads the international effort to integrate the scientific community with research interests in the cave and its vicinity. This effort is intended to lead to better science, a more comprehensive picture of the cave system, and increased international cooperation.

Salt Basin Aquifer Assessment

The Salt Basin Project deals with current and proposed exploitation of the groundwater resources of the Salt Basin, a tectonic depression of mostly Permian-age carbonate rocks that straddle the southern New Mexico/Texas border. Prior to agricultural development, groundwater discharged to saline playas in the middle of the



basin, hence the feature's name. The cities of El Paso in Texas, Las Cruces in New Mexico, and Ciudad Juarez, Chihuahua, Mexico, have expressed strong interest in the basin as a potential future water source to supplement their currently supplies.

This three-year project is sponsored by the Interstate Stream Commission and co-managed between Dr. Penelope Boston and NMT Hydrology Professor, Dr. Fred Phillips. Two NCKRI student scholars, Andre Ritchie and Sophia Sigstedt, are concluding the hydrological assessment of the basin. Mr. Ritchie is on schedule to defend his Master's thesis in fall 2009.

NASA Planetary Biology Intern Program

For the third consecutive year, Dr. Penny Boston has hosted a NASA Planetary Biology Intern. This year's intern is Celeste Asikainen, from the University of Massachusetts Amherst, and she works under Dr. Lynn Margolis.

Ms. Asikainen is studying microbial structures produced at the bottoms of deep cold lakes in New England. The structures are composed of iron and manganese materials intermixed with living materials. There are striking similarities and instructive differences between her study subjects and cave ferromanganese structures and desert varnish deposits, long studied by Dr. Boston and her colleagues. Ms. Asikainen will continue her research at her home university during the fall of 2009 and return again to NMT in early 2010 to continue to work with Boston's team.

Micrometeorology of Caves

The Cave and Karst Program is developing physics-based models of micrometeorological processes in caves in conjunction with Dr. John Wilson and Dr. Anders Jorgensen of NMT, Dr. Scott Tyler of the University of Nevada Reno, and Paul Burger of Carlsbad Caverns National Park. Master's student Ravindra Dwivedi is nearing completion on the modeling efforts and plans to defend his thesis in fall 2009.

Student Awards

Megan Curry and Laura Rosales-Lagarde received the Marie Curie Grant from the Karst Research Institute, Scientific Research Centre of the Slovenian Academy of Sciences and Arts, Postojna, Slovenia. The grant allowed them to attend the 16th International Karstological School in Slovenia in 2008

Student Presentations

Rosales-Lagarde, L., P.J. Boston, M. Pullin, A. Campbell, K.W. Stafford. 2009. Clasificación del agua de manantiales y su relación con la formación de cavernas en la región de la Sierra de Tabasco, Norte de Chiapas, México. Paper presented at the IX Congreso Nacional Mexicano de Espeleología, January 30 - February 2, in Villahermosa, Tabasco, Mexico.

Rosales-Lagarde, L., A. Campbell, P.J. Boston, K.W. Stafford. 2008. Sulfur and oxygen isotopes: evidence of H₂S spring sources, southern Mexico. Paper presented at the Goldschmidt Conference, July 13-18, Vancouver, Canada.

Student Publications

Boston, P.J., M.N. Spilde, D.E. Northup, M.C. Curry, L.A. Melim, and L. Rosales-Lagarde. 2009. Microorganisms as speleogenetic agents: Geochemical diversity but geomicrobial unity. In *Special Paper 1, Hypogene Speleogenesis and Karst Hydrology of Artesian Basins*, eds., A.B. Klimchouk & D.C. Ford, 51-58. Simferopol, Ukraine: Ukrainian Institute of Speleology & Karstology.

Curry, Megan, Penelope J. Boston, Mike Spilde, James F. Baichtal, Andrew R. Campbell. 2009. Cottonballs, a unique subaqueous moonmilk, and abundant moonmilk in Cataract Cave, Tongass National Forest, AK. *International Journal of Speleology* 38(2): 111-128.

Rosales-Lagarde, L., P.J. Boston, A. Campbell, M. Pullin. 2009. Villa Luz Park Caves: Speleogenesis Based on Current Stratigraphic and Morphologic Evidence. In *Special Paper 1, Hypogene Speleogenesis and Karst Hydrology of Artesian Basins*, eds., A.B. Klimchouk & D.C. Ford, 245.

Simferopol, Ukraine: Ukrainian Institute of Speleology & Karstology.

Rosales-Lagarde, L., Penelope J. Boston, Andrew Campbell, Kevin W. Stafford. 2008. Possible structural connection between Chichón Volcano and the sulfur-rich springs of Villa Luz Cave (a.k.a. Cueva de las Sardinias), southern Mexico. In *Association of Mexican Caves Studies Bulletin 19 and Sociedad Mexicana de Exploraciones Subterráneas Boletín 7: Proceedings of the X, XI and XII Symposium of Vulcanospeleology*, eds. R. Espinasa-Pereña and J. Pint, 177-184. Austin: Texas.

Stafford, Kevin W., Dana Ulmer-Scholle, Laura Rosales-Lagarde, Laura. 2008. Hypogene calcitization: evaporite diagenesis in the western Delaware Basin. *Carbonates and Evaporites* 23(2): 89-103.

Rosales-Lagarde, L., M. Tobler, and M. Plath. 2008. Posibles amenazas y soluciones para la preservación de la Cueva de las Sardinias y sus formas de vida y características únicas. *Mundos Subterráneos*.

Student Support at Other Universities

NCKRI's broader educational outreach efforts extend to universities outside of New Mexico Tech. General support through information and ideas 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):

- Kyle Cunningham is completing a Master's degree in environmental science; her thesis examines the effects of extinguishing a giant mulch pile fire on the karstic Edwards Aquifer and developing effective groundwater quality monitoring programs for private wells drawing from karst aquifers.
- Keith Muhlestein has recently entered a doctoral program in geology; his dissertation will study thermal imaging of caves and karst features and their application to environmental assessments of karst areas.

OUTREACH

Partnership Meetings

Developing partnerships is key to NCKRI current growth and future success. Executive Director Dr. George Veni has led this effort and this year met in person and by teleconference with many people and organizations, include the Karst Waters Institute Board of Directors, the National Park Service Cave Inventory and Monitoring Team, and the U.S. Forest Service. Other partnership efforts are outlined below.

- As an advisor to Western Kentucky University's Applied Research and Technology Program, Dr. Veni attends advisory board meetings in Bowling Green. He followed this year's meeting by meeting with staff and directors of the Mammoth Cave International Center for Science and Learning, and the university's Hoffman Environmental Research Institute and Department of Geography and Geology.
- NCKRI co-organized a multi-agency planning meeting for developing and promoting current best management strategies in caves and karst. All agreed that NCKRI would take the lead in developing future conferences and publications on this topic.
- Dr. Boston continued a long term advisory relationship with the Museum of Science and Industry in Chicago in their development of a major exploration-oriented field science exhibit scheduled to open in 2012.
- Dr. Veni serves as Adjunct Secretary on the Bureau (governing board) of the Union Internationale de Spéléologie (UIS). During the annual Bureau meeting, which occurred in the Republic of Korea in 2008, he teamed NCKRI with the UIS and the Società Speleologica Italiana to create a cave education DVD for free distribution at the 15th International Congress of Speleology.

Conferences

NCKRI has attended, sponsored, and/or had a booth at numerous conferences, such as:

- 4th European Congress of Speleology, Vercors, France (August 2008)
 - 13th International Symposium on Vulcanospeleology, Jeju Island, Republic of Korea (September 2008)
 - Geological Society of America Convention, Houston, Texas (October 2008)
 - Society for Advancement of Chicanos and Native Americans in Science Conference, Salt Lake City, Utah (October, 2008)
 - Symposium on Applications of Geophysics to Engineering and Environmental Problems, Fort Worth, Texas (March 2009)
 - International Conference on Hypogene Speleogenesis and Karst Hydrogeology of Artesian Basins, Chernivtsy, Ukraine (May 2009)
 - Several national and regional speleological conferences in the US.
- Additionally, NCKRI is a major sponsor of the 15th International Congress of Speleology scheduled for July 19-26, 2009 in Kerrville, Texas, by providing both staff and financial support. Dr. Veni is the Congress Chairman and several members of NCKRI's board serve on the Congress Organizing Committee. Roughly 1,500 speleologists from about 50 countries are expected to participate.



Community Involvement

NCKRI:

- Participated in the Carlsbad Chamber of Commerce's yearly Business Fair
- Joined a team of federal agencies in the Carlsbad area (Bureau of Land Management, National Park Service, and U.S. Forest Service), to sponsor and participate in *Relay for Life*, a nationwide campaign to raise awareness and funds to fight cancer
- Attended regular meetings of Carlsbad Chamber of Commerce, Carlsbad Department of Development, and Carlsbad Rotary Club.

Guest Speakers

NCKRI's Drs. Lewis Land and George Veni were invited to speak at or give presentations to:

- Pecos Valley Grotto, National Speleological Society: *Hypogenic speleogenesis within Seven Rivers evaporites: Coffee Cave, Eddy County, New Mexico*
- Carlsbad High School Education Week: *Very large holes in the ground and how they got there*
- Pecos Valley Grotto, National Speleological Society: *Anthropogenic sinkholes in the Delaware Basin region of west Texas and southeastern New Mexico*
- Bottomless Lakes State Park Enchanted Evenings presentation: *Sinkholes and karst aquifers in southeastern New Mexico and west Texas*
- Chihuahuan Desert Conservation Alliance in Carlsbad, New Mexico: *Fragile Earth: Sinkhole Causes, Risks, and Management*
- Albuquerque High School, New Mexico, on cave science and exploration
- Several groups of New Mexico high school counselors as part of an ongoing recruitment program sponsored by the New Mexico Institute of Mining and Technology's Admissions Office.

Distinguished Lecture

Dr. George Crothers gave a presentation on his 15 years of archeological research at Mammoth Cave, Kentucky. The Distinguished Lecture series is well-attended and given to the citizens of Carlsbad.

Media

Major showcasing of NCKRI geomicrobiology research appeared in a National Geographic television special, *Giant Crystal Caves*, and a Discovery Channel broadcast, *Josh Bernstein: Into the Unknown*.

Dr. Boston led a public television sponsored science café on cave science and microbiology.

NCKRI staff were interviewed for, or contributed to, reports in or by:

- The Santa Fe New Mexican newspaper on construction of NCKRI Headquarters
- Newspapers in New Mexico and Texas
- KOBR TV station in New Mexico on the Groundbreaking Ceremony of NCKRI Headquarters
- An interview featuring the headquarter's bat roost was on KBIM/KRQE TV stations in New Mexico
- Interviews for radio stations in Artesia and Carlsbad, New Mexico and San Antonio, Texas.

The NCKRI Board of Directors met twice this year: October 2008 in Houston, Texas, in conjunction with the Geological Society of America Convention, and in June 2009 in Carlsbad, New Mexico, which included an inspection of construction at NCKRI Headquarters. The Executive Committee met 10 times via telephone.

There was one change on the board this year, Carol McCoy (the National Park Service Director) retired and David Steensen was appointed as the Director representing the National Park Service. Carol's service was greatly appreciated by the board and will be missed.

Following are some of the Board's activities during the year:

- Defined Award Guidelines
- Defined items to be included in the office Standard Operating Procedures, which will be reviewed annually by the Executive Committee
- Worked on Research Grant Guidelines
- Hired an Education Director, Dianne Gillespie, who is tasked with the education, museum, and book-

BOARD ACTIVITIES

store programs

- Held Groundbreaking Ceremony for construction of NCKRI headquarters.
- Continued support of the Karst Information Portal, a joint project of NCKRI, the University of South Florida, the University of New Mexico, and the Union Internationale de Spéléologie.

NCKRI also sponsored work by graduate and undergraduate students at New Mexico Tech and The University of Texas at San Antonio. Several of these projects have been multiple year efforts. See the *Student Activities* section for details.

NCKRI sponsored two major events this calendar year, the Hypogene Speleogenesis meeting in the Ukraine in May 2009, and the 15th International Congress of Speleology to be held in July 2009 in Kerrville, Texas.

NCKRI also donated money to the National Speleological Society to help study and fight White Nose Syndrome, a devastating and mysterious affliction that has killed nearly 1 million bats in the northeastern US.



Tourists at Mammoth Cave's historic River Styx Spring, Mammoth Cave National Park, Kentucky.

Photo by George Veni

BOARD OF DIRECTORS

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.

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

Carol McCoy

Member from July 2007 to January 2009; permanent position representing the National Park Service (NPS); Law Degree, Master's Degree in Public Policy, Bachelor's Degree in Environmental Studies. Carol is the Chief

of the Planning, Evaluation and Permits Branch of the NPS Geologic Resources Division; she manages a multi-disciplinary staff that provides policy and technical expertise to all levels of the NPS organization on a variety of geologic and minerals management issues, including cave and karst resource stewardship. She has also worked for a law firm, the U.S. Environmental Protection Agency, and George Washington University.

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.

Dr. Ronald T. Green

Member since 2007; Bachelor's in Industrial Engineering; Bachelor's in Geology; Master's in Geophysics; PhD in Hydrology. Ron is a Hydrogeologist with the Southwest Research Institute, San Antonio, Texas.

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; PhD 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.

Dr. Kathleen Lavoie

Member since 2006; PhD 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. Donald McFarlane

Member since 2005; Bachelor's and Master's Degrees in Zoology and a PhD in Ecology. Donald is a Professor of Biology, The Claremont Colleges, California. His professional interests are in Late Pleistocene mammalian extinctions and paleo-ecological records from caves. He has been caving since 1973, and done research in the West Indies, Mexico, Ecuador, Europe, Kenya, New Zealand, Malaysia, and the U.S.

Dr. Diana Northup

Member since 2006; PhD 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 in-

teractions with rock surfaces in caves and in desert varnish.

Randall Orndorff

Member from December 2000-2004 and 2006 to June 2009; Bachelor's and Master's degrees in geology. Randy is currently the Associate Program Coordinator for the US Geological Survey (USGS) National Cooperative Geologic Mapping Program. He has been with the USGS since 1981 as a geologic mapper and expert on Cambrian-Ordovician carbonate rocks in the Central Appalachians and Ozarks. His karst work includes geologic controls and frameworks on karst development of the Appalachians and Ozarks.

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 directs the 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. Jerry Trout

Charter board member; PhD in Education. Jerry is with the US Forest Service (USFS) at the Coronado National Forest in Tucson, Arizona; he coordinates all phases of cave management, conservation, and research for USFS in the US. He became the first cave specialist for

USFS in 1972. Jerry's first caving trip was in Carlsbad Cavern in 1947.

Dr. H. Len Vacher

Member since 2005; PhD 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*.

NOTES:

During this past fiscal year:

- *Carol McCoy retired from the Board in January 2009 and Dave Steensen was appointed by the National Park Service to replace her*
- *Randall Orndorff retired from the Board and Dave Weary of the US Geological Survey was elected as his replacement in June 2009*
- *Donald McFarlane and Jerry Trout also retired from the Board, and their replacements, Todd Chavez (University of South Florida) and Ronal Kerbo (retired, NPS), were elected in August 2009.*

See next year's report for more information on the new Board members.



Aerial view of NCKRI Headquarters under construction, April 25, 2009.

Photo by Larry Pardue

NCKRI STAFF

Dr. George Veni, Executive Director

Dr. Veni is an internationally recognized hydrogeologist specializing in caves and karst terrains. Prior to NCKRI, he owned and served as principal investigator of George Veni and Associates for more than 20 years. He has also 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, and as Adjunct Secretary of the Union Internationale de Spéléologie since 2002. He has also served as a member of the geological and biological dissertations at The University of Texas and teaches karst geosciences courses as an adjunct professor for Western Kentucky University. He has published and presented over 150 papers, including five books, on hydrogeology, biology, and environmental management in karst terrains.



Dr. Penelope Boston, Academic Program Associate Director

Dr. Boston administers NCKRI's Cave and Karst Studies program at New Mexico Tech. She teaches classes in cave and karst science, geomicrobiology, astrobiology, and global systems, and supervises graduate students studying those topics. Dr. Boston received a National Research Council Postdoctoral Fellowship at NASA-Langley Research Center in Virginia, has held positions at NCAR, the University of Colorado, University of New Mexico, and founded and operated her own non-profit research institute (Complex Systems Res., 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 of the *Journal of Cave & Karst Studies*.

Dianne Gillespie, Associate Director of Education



Ms. Gillespie began working for NCKRI on June 22, 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.

Prior to joining NCKRI, Dr. Veni conducted dye traces (left) and related research to study groundwater flow in karst aquifers.

Photo by Jim Wolff

***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),



Dr. Lewis Land scuba diving into a karst spring to collect water samples.

Photo by Geoff Rawling

and served for five years on the NMGS Executive Committee.

***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.

***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,
NCKRI Administrative Coordinator***

STAFF PUBLICATIONS

Published Reports and Journal Articles

Banner, Jay, George Veni, Brian Cowan, and Elizabeth McGee. 2008. *Geomorphic and hydrochemical history of the Edwards Aquifer at Inner Space Cavern*. Guidebook for Geological Society of America Field Trip No. 411, 2008 Geological Society of America Convention, Houston, Texas, 47.

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Curry, M., P.J. Boston, M.N. Spilde, J. Baichtal, and A. Campbell. 2009. Cottonballs: A unique subaqueous moonmilk, and abundant subaerial moonmilk in Cataract Cave, Tongass National Forest, Alaska. *International Journal of Speleology* 38(2): 111-128.

Land, L. 2009. Anthropogenic sinkholes in the Delaware Basin Region: west Texas and southeastern New Mexico. *West Texas Geological Society Bulletin* 48: 10-22.

Land, L. and P. Burger. 2008. Rapid recharge events in a karstic aquifer: an example from Lake of the White Roses, Lechuguilla Cave,



Photo by George Veni
Dr. Jay Banner of the University of Texas at Austin (UT) points out recent flood lines during a joint NCKRI-UT geology field trip to Inner Space Cavern, Texas, for the 2008 Geological Society of America Convention.

NM. In *ASCE Geotechnical Special Publication no. 183: Proceedings of the Eleventh Multidisciplinary Conference on Sinkholes and the Engineering and Environmental Impacts of Karst*, eds. L. Yuhr, E.C. Alexander, Jr., and B. Beck, 396-403. Tallahassee: Florida.

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examples from the Lower Pecos Region of New Mexico, USA. In *NCKRI Symposium 1, Advances in Hypogene Karst Studies*, Kevin W. Stafford, Lewis Land, George Veni, eds., 149-156.

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Melim, L.A., D.E. Northup, M.N. Spilde, B. Jones, P.J. Boston, and R.J. Bixby. 2008. Reticulated filaments in cave pool speleothems: Microbe or mineral? *Journal of Cave and Karst Studies* 70: 135-141.

Rosales-Lagarde L., A. Campbell, P.J. Boston, and K.W. Stafford. 2008. Sulfur and Oxygen isotopes: Evidence of H₂S spring sources,

Southern Mexico. *Geochimica et Cosmochimica Acta* 72(12): A805-A805.

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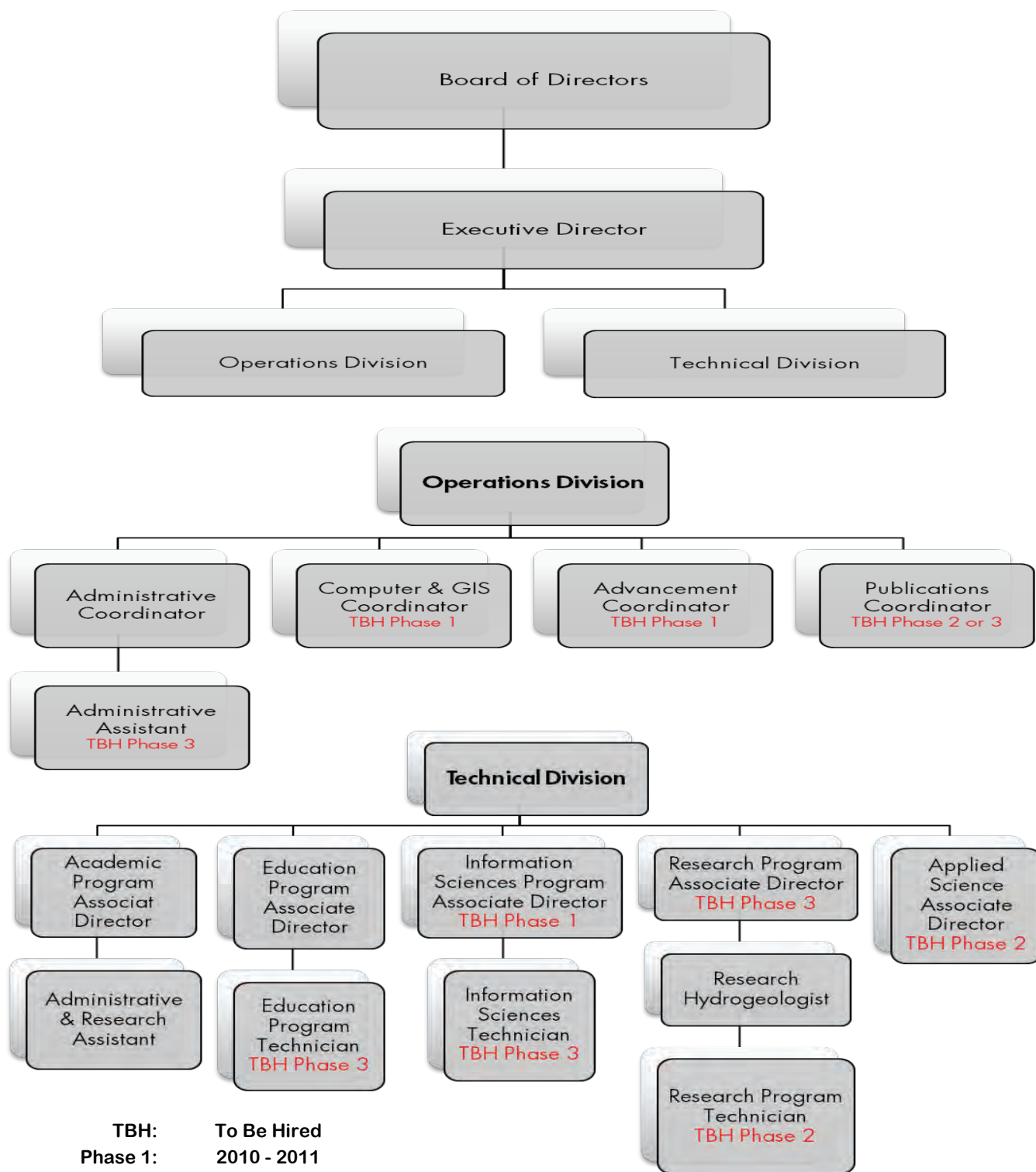
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NCKRI investigated this 12-m deep soil sinkhole in southern New Mexico that swallowed a bulldozer and driver in December 2008; the driver was not hurt.

Photo by George Veni

ORGANIZATIONAL STRUCTURE

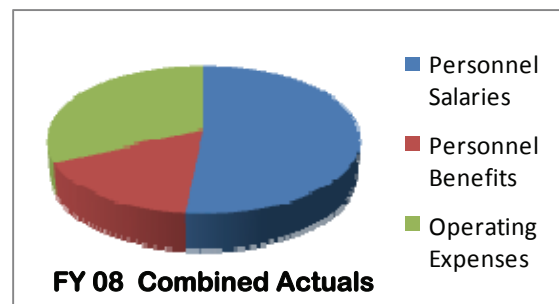
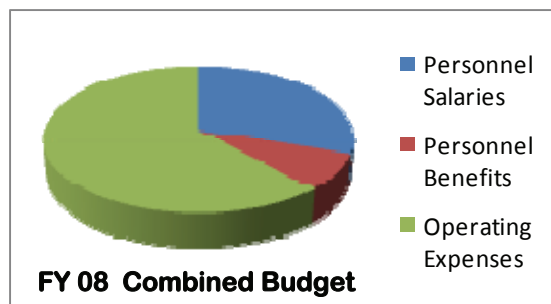


TBH: To Be Hired
Phase 1: 2010 - 2011
Phase 2: 2011 - 2012
Phase 3: 2012 - 2013

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

2008-2009 BUDGET

	<i>National Park Service</i>		<i>State of New Mexico</i>		<i>COMBINED</i>	
	FY08 Budget	*FY08 Actuals	FY08 Budget	FY08 Actuals	FY08 Combined Budget	FY08 Combined Actuals
PROJECT SALARIES						
Staff	178,743	98,161	141,409	149,131	320,152	247,292
Students			50,000	12,663	50,000	12,663
Project Salaries Sub-total	178,743	98,161	191,409	161,794	370,152	259,955
FRINGE BENEFITS						
Staff	57,198	36,017	40,091	46,665	97,289	82,682
Students			1,000	365	1,000	365
Fringe Benefits Sub-total	57,198	36,017	41,091	47,030	98,289	83,047
TOTAL PERSONNEL EXPENSE	235,941	134,178	232,500	208,824	468,441	343,002
PROJECT FUNDS						
NCKRI funds to USGS to publish cave meeting proceedings	2,000	2,000			2,000	2,000
OPERATING EXPENSES						
Maintenance Fund/Rent					12,500	12,500
Utilities and janitorial						
Supplies & Expense	9,615	40,931	64,800	29,534	74,415	70,465
Telephone Equipment Charges		330	2,000	1,026	2,000	1,356
Travel	15,000	20,386	38,000	5,843	53,000	26,229
Equipment			539,534		539,534	
Programs	18,000	5,000		1,540	18,000	6,540
NMT Administrative Support			25,000	20,000	25,000	20,000
NMT "Indirect" from NPS Budget	22,444	16,066			22,444	16,066
NPS "Indirect" to GRD at 6% on NPS appropriation	20,000	20,000			20,000	20,000
TOTAL OPERATING EXPENSE	85,059	102,713	669,334	57,943	754,393	160,656
TOTAL ALL EXPENSES	321,000	236,891	901,834	266,767	1,222,834	503,658



STRATEGIC PLANS

The following is a partial list of goals for NCKRI's Strategic Plan, presented relative to the fiscal year which begins annually on July 1. Goals are presented in a combined order of priority and chronology. The goals are generally described in broad terms, and are not exclusive or described to their full extent. Many additional facets and details will be developed and presented in a forthcoming NCKRI Business Plan. Annual evaluations of progress toward the goals and overarching concepts are understood as included.

Vision Statement

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.

FY 2009-2010

- Hire an Advancement Coordinator.
- Continue construction of NCKRI headquarters (includes development

of museum exhibits and the purchase of office and lab equipment).

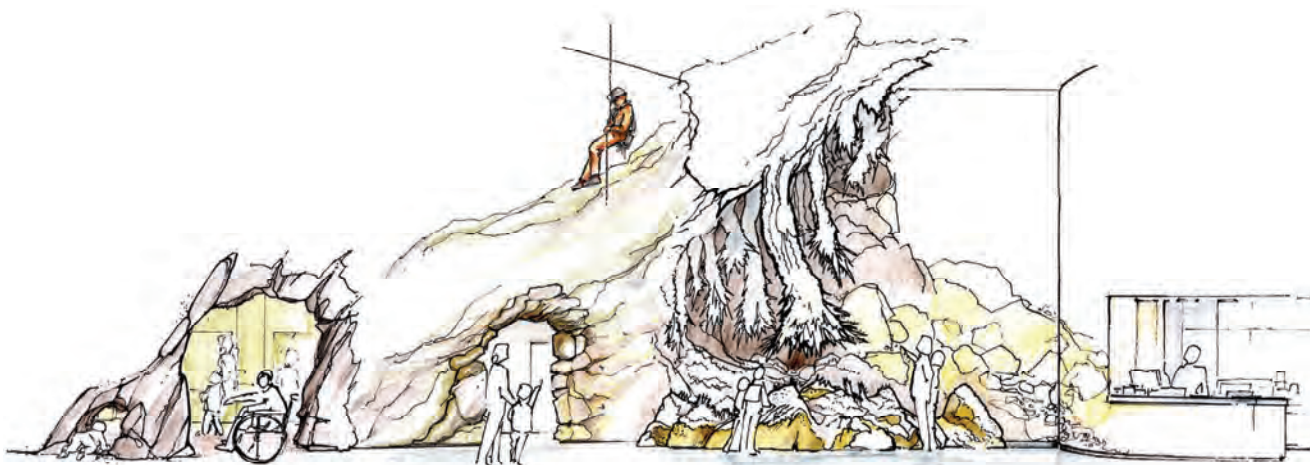
- Conduct building-related fundraising to fund additional or superior exhibits, equipment, and construction, and to endow key staff positions and projects.
- Continue to promote use and development of the Karst Information Portal.
- Develop lists of potential research projects and sponsors/partners for those projects, and begin working with the most likely and/or crucial projects and sponsors.
- Begin local karst education series program.
- Begin a national karst education program with curricula for K-12 and universities, and outreach programs for agencies and organizations.
- Complete development of a cooperative agreement with the Carlsbad Caverns/Guadalupe Mountains Natural History Association for the operation of the NCKRI bookstore.
- Begin preparation of NCKRI-specific materials that will be ready for sale in the bookstore when NCKRI Headquarters is opened to the public.
- Investigate possibilities with the National Speleological Society on

NCKRI supporting and/or assisting with the production of the Journal of Cave and Karst Studies

- Conduct research and begin preparation to establish a NCKRI Foundation.
- Write an updated business plan.
- Develop job descriptions to select personnel when NCKRI Headquarters is complete and funding allows the hiring of additional staff.

FY 2010-2011

- Move into NCKRI Headquarters.
- Hire staff as warranted by funding and the most critical needs.
- Establish a NCKRI Foundation.
- Continue high-level national and international public relations campaigns for fund and partnership building associated with the grand opening of NCKRI Headquarters.
- Submit proposal to the National Science Foundation to establish an international cave sample archive facility; the grounds would be large enough to later construct additional facilities as needed (some possibilities are discussed below).
- Begin intensively initiating national partnerships, projects, and associated



Conceptual drawing of exhibits in NCKRI Headquarters lobby; this view flattens a curved area. To the right is NCKRI reception/information and the bookstore entrance. Straight ahead will be an accurate and precise partial recreation of the Chandelier Ballroom in Lechuguilla Cave, Carlsbad Caverns National Park, New Mexico. Large and small cave entrances lead to the exhibit hall and restrooms. A manikin dressed in appropriate caving equipment hangs from the ceiling, demonstrating proper rappelling technique.



Conceptual layout of NCKRI Headquarters' exhibit and museum area. Visitors will enjoy a cave-like experience as they enter through the indirectly lit Twilight Zone foyer exhibit and progress into darker cave zones that feature exploration (below), the sciences, and management and protection of karst terrains. NCKRI conceptual exhibit plan and drawings provided by Frank Binney and Associates.

fund-raising, with the goal of establishing a consortium that can work more effectively to solve basic and applied problems, and be more competitive in receiving funding.

- Begin development of an international karst research coalition, to include a network of laboratories and field research sites (ICKL: International Cave and Karst Laboratories).
- Establish a Carlsbad Spring monitoring program with the City of Carlsbad and other partners to have a live-feed display in the headquarters building when it is completed, and as part of regional self-guided and NCKRI-guided educational tours.
- Begin a series of traveling karst museum exhibitions with partners, using NCKRI classroom space when not needed for classes or conferences to present exhibitions created by NCKRI

or its partners; exhibitions should be funded by sponsors, with some costs covered by entry fees when necessary.

FY 2011-2012

- Reestablish the NCKRI Visiting Scholar Program, preferably as an endowed position.
- Conduct follow-up *Future Directions in Karst Research Workshop* focused on applied research issues, which will serve as an impetus to...
- Begin a regular publication series for NCKRI, *Current Best Practices in Karst Science*, to fill a critical need of research scientists and environmental managers.
- Begin regular production of a new publication series, *National Report on the Status of Caves and Karst*, to establish NCKRI as the leader in karst

science.

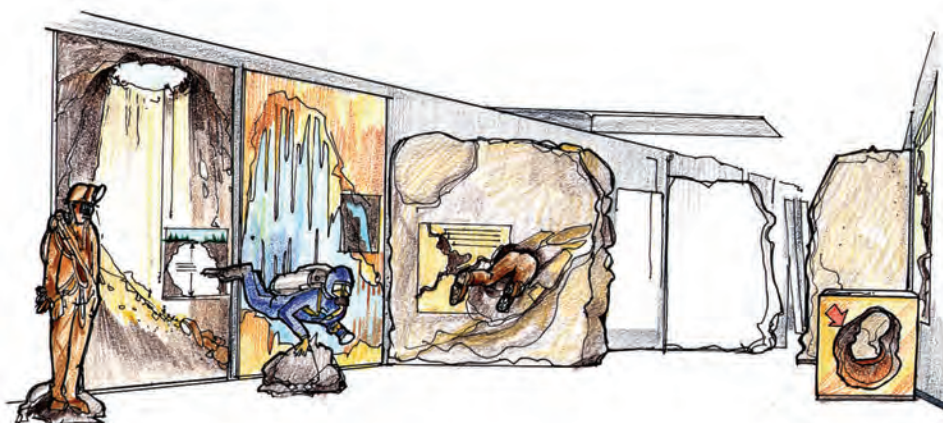
- Begin development of a NCKRI video that can be shown at NCKRI Headquarters, as well as other venues, that promotes the importance of caves and karst and the need for the proper stewardship.
- Begin a student research grant and internship program tied to NCKRI projects and partners.

FY 2012-2014

- Karst education program is established with major universities and agencies.
- Complete development of an international karst research coalition, to include a network of laboratories and field research sites (ICKL: International Cave and Karst Laboratories).
- Begin development of an international karst research coalition, to include a network of laboratories and field research sites.

FY 2014-2019

- Complete development of an international karst research coalition.
- Construct a facility separate from NCKRI headquarters for research laboratories, archival storage of cave samples and library materials, and as a field station for visiting scholars and students.





National Cave and Karst Research Institute
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