TECH TONICS
New Mexico Tech Department of Earth and Environmental Science
www.ees.nmt.edu
Alumni Newsletter
May 2005

Penny Boston sampling "moonmilk" in Spider Cave, NM. This pasty white calcite material is produced by the interactions of groundwater, cave bedrock, and microorganism activities. *Image © V. Hildreth-Werker*

New Cave and Karst Studies

By Penny Boston, Associate Professor of Cave and Karst

On the third floor of the MSEC building at New Mexico Tech, photographs of some of the world's most beautiful caves vie with images of future robotic exploration devices destined for the planet Mars. Glamor pin-ups of favorite cave microorganisms compete for wall space with different models of cave formation in materials from limestone to rock salt. In the corner of the Cave and Karst Lab, experiments to reproduce cave formations like stalactites and stalagmites are underway. This is the home of the new Cave and Karst Studies (CKS) specialization under the direction of Dr. Penelope J. Boston.

CKS, a specialization under both the Geology/Geochemistry and Hydrology Programs, is devoted to cave science in all its many forms. It was instituted in conjunction with the founding of the new National Cave and Karst Research Institute in Carlsbad, NM. Jointly funded by the State of New Mexico and the federal government through the National Park Service, this new institute has an ambitious mandate: to promote cave and karst science, to further education and public awareness of this unique underground wilderness, to assist those who manage such resources to develop best practices, and to provide a flagship for national and international efforts to enhance speleology and conservation of cave and karst terrain.

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Large subsidence sinkhole lake in gypsum karst terrain at Bottomless Lakes State Park, NM. *Image © 2005 by Kevin Stafford*

Pool fingers and *webulites:* lithified remains of fossil microbial cave mats in a paleopool in Carlsbad Cavern, NM. *Image © 2002 by Kenneth Ingham*

Penny Boston came to NMT in Fall 2002 to develop an academic program to serve as the intellectual underpinning of the new federal institute. Cave and Karst Studies at NMT is about to graduate its first Hydrology Master's student and currently has four additional graduate students who are just completing their first year in the specialization. CKS has taken on one new graduate student for Fall 2005 and another two are anticipated in Spring of 2006. Two undergraduates are currently working on their senior theses in CKS and another is scheduled to begin in Fall of 2005.

Among the long-term projects in CKS is a study of the role of sulfuric acid in the creation of certain types of caves (including Carlsbad Cavern and Lechuguilla Cave in southeastern NM) and

Sampling the high gas emissions at one of the over 25 hydrogen sulfide emitting springs in Cueva de Villa Luz, Tabasco, MX. *Image © 2000 by Kenneth Ingham*

the unique minerals and microbiological communities associated with this process. Study sites in a number of ancient New Mexico caves and in modern active sulfur cave systems in Tabasco, Mexico are the primary sites for this study.

A very long term study of the unique iron and manganese deposits in Lechuguilla Cave, Spider Cave, and others in New Mexico and Jewel Cave in South Dakota is looking at the chemistry, mineralogy, and microbiology involved in production of this "speleosol," a type of soil produced in the subsurface environment.

Exploration and study of caves on other planets, especially Mars, are an active area of investigation. The CKS team is developing methods for locating and studying caves on Mars, Earth's Moon, and other bodies in the Solar System. Collaborative projects with both the Field and Space Robotics Laboratory at MIT in Boston, MA, and with the Jet Propulsion Laboratory in Pasadena, CA, are allowing field tests of such devices in Earth caves from New Mexico to Saudi Arabia and Antarctica.

NMT Cave and Karst Studies has attracted significant media attention with Boston's work featured in a PBS NOVA "Mysterious Life of Caves" broadcast in October of 2002 and another NOVA "Origins" broadcast in October of 2004. Research in CKS has appeared in numerous print and broadcast media both locally, nationally, and internationally including NHK (Japan), BBC (UK), Eurovision (Spain), CNN, ABC, National Geographic TV, Discovery Channel, Discovery Canada, The Learning Channel, and many others. An article by Boston even appeared in *WIRED Magazine* (Dec. 2004).

Andrew R. Campbell
Department Chairman
Professor of Geology

Note from the Chair

I hope this newsletter finds you well and prosperous. The last few years have been ones of growth for the Department. We are currently finishing a search for two new geophysicists: one to replace John Schlue who is retiring after 30 years at NMT, and the other to work with the growing EarthScope presence on campus. We will then be at an all time high of 21 regular faculty members—including five professors in geophysics—finally a critical mass to really expand the program. I know you will be hearing a lot from that group in the future.

During a time when geoscience programs across the nation are shrinking, we have managed to maintain our recent enrollment numbers. We currently have about 60 undergraduate majors and 70 graduate students. Our future plans include a fund raising effort to enhance the student experience by providing resources (sponsored field trips, assistant-ships, social events, etc.) not possible with our current funding.

This is my last year as Chairman. It has been a learning and rewarding experi-ence, but I can't say I am sad to return to teaching, research, and my stable isotope lab, all of which have suffered from neglect during the last three years. Thanks to all of you who have sent me messages of encouragement during my term. In July 2005, I will be turning the reins over to the very capable hands of Dr. Rob Bowman. Good Luck Rob!

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Hydrology Program Update

By Rob Bowman, Professor of Hydrology

The Hydrology Program at New Mexico Tech was founded in 1956 by Mahdi Hantush. Hantush and those who later joined him focused primarily on research in groundwater hydrology. For the next forty years, faculty and students here continued to emphasize subsurface hydrology. Somewhat ironically, during this time relatively little research was done related to the Rio Grande, the "lifeblood of New Mexico," which passes only a few miles east of the campus.

The Rio Grande five miles NE of Socorro. ***Image © 2001 by Peter Mozley***

In recent years our attention has turned more and more toward the Rio Grande. This change was stimulated by the addition of faculty having interests in land surface processes and remote sensing, and funding at the state and national levels for large-scale, coupled groundwater/surface-water investigations.

About five years ago, NMT joined the University of Arizona and other research institutions to form the NSF Science and Technology Center SAHRA (Sustainability of Arid Hydrology and Riparian Areas). SAHRA is headquartered at the U of A and involves six major partner universities and two national laboratories in the western United States. Research focuses on two river basins: the upper Rio Grande in Colorado, New Mexico, Texas, and Chihuahua; and the San Pedro River in Arizona and Sonora. Among the areas of investigation in the Rio Grande are the role of vegetation in runoff and groundwater recharge, water demand and water banking, high-resolution hydrologic modeling of the entire basin, and salinization of the Rio Grande. SAHRA-funded studies on the interaction of vegetation and vadose-zone hydrology recently led to a publication in *Science* on nitrate in desert soils.

In collaboration with the University of New Mexico and New Mexico State University, NMT's Hydrology Program recently received funding from the National Science Foundation to establish infrastructure to provide high resolution, high frequency estimates of evapotranspiration (ET) over New Mexico. Building upon existing ground-based instrumentation, we plan to establish a network of 16 state-of-the-art flux towers in different ecotones, concentrating on the riparian, agricultural, and forested areas of the Rio Grande watershed. These point measurements will be used to calibrate and validate estimates of ET based on spectral data collected by satellites. The satellite-based estimates will be converted to GIS format and posted on the Internet for use by researchers, water managers, and water users including farmers. The comprehensive ET information will feed into improved distributed models for predictions of runoff, soil moisture availability, and streamflow.

A major effort currently underway is to establish a Rio Grande Integrated Observatory (RIO) as a national resource for research in basin-scale hydrology. We've defined the RIO as the watershed from the headwaters in Colorado south to Fort Quitman, Texas, below El Paso. Under the auspices of the Consortium of Universities for Hydrologic Research, Inc. (CUAHSI), the RIO would be one of several observatories across the nation. The CUAHSI observatories are envisioned as highly instrumented watersheds that will provide core data and research opportunities for hydrologists, biologists, and other natural scientists who can access data from their home institutions or come to the observatory to perform their own focused investigations. If we are successful in securing funding for the RIO, we will further cement NMT's reputation as a major center for hydrology research and training.

Faculty Spotlight

Susan L. Bilek
Assistant Professor of Geophysics

I arrived here at New Mexico Tech in August 2003 after getting my PhD at the University of California, Santa Cruz, and a postdoctoral appointment at the University of Michigan. My primary research interests revolve around understanding earthquake rupture processes, with much of the work focusing on earthquakes in shallow subduction zones. These regions produce the majority of the global seismicity as well as damaging tsunamis, so research in this area has significant societal impact.

One aspect of my research involves understanding the connections between heterogeneity on the fault plane contact and variability in earthquake locations and behavior of rupture. It appears that regions of high slip during several large subduction zone earthquakes occur in areas where features such as seamounts and ridges enter the subduction trench. Some of the results of my work have made specific connections between these geologic features entering the subduction zone and details of the history of earthquake rupture in Costa Rica.

Current extensions of these research projects include a newly funded effort to create 3D models of subduction zones to examine the impact of subducting seamounts on the stress conditions in and around the fault plane as well as proposals for a large seismic, geodetic, and hydrologic experiment off the western coast of Nicaragua. In addition, I have a graduate student examining details of Alaskan earthquakes and an undergraduate student focusing on defining catalogs of earthquakes in the Japan subduction zone.

Closer to home, I have also started to work with New Mexico earthquakes, helping with upkeep of the local network and catalog. In addition, I've been forming new collaborations with other

scientists in the region with future projects planned to integrate seismic and geodetic information about the Socorro Magma Body and Rio Grande Rift. It's a great opportunity to move some of my research focus on earthquakes to the most seismically active area of New Mexico!

I've also been busy teaching several new courses in the Geophysics Group. During Spring 2004, I developed a course in Observational Seismology (Geophysics 524). It was a good experience for students to get hands-on training in seismological methods, such as basic earthquake location and using seismograms to exam-ine the structure of the Earth. Plus, the class got practical experience in the field by helping to install a new local seismic station in the Quebradas (see photo). During Fall 2004, I offered Tectonophysics

Students in the Observational Seismology course (GEOP 524) and Dr. Rick Aster, another Geophysics faculty, happily digging a hole for the installation of seismic station CAR in the Quebradas.

(Geophysics 525) for both graduate and undergraduate students. Topics included quantitative treatment of heat flow, fluid flow, gravity, Earth rheology, and earthquakes. Finally, in Spring 2005, I am offering a brand new course for undergraduates covering natural disasters facing the planet. I'm very excited about this course—it will be fun to have an opportunity to teach (and hopefully attract) new undergraduates in geology and geophysics!

On a personal note, my husband Glenn and I are definitely enjoying the outdoor recreation in and around Socorro, as we are frequent hikers with our new puppy up in the Magdalenas. We also did the M-Mountain climb during this year's 49ers weekend.

News and Notes

November 2004 Hailstorm

Grad student Dylan Canales outside MSEC during hailstorm

What began as an interesting variation to the uncommon rainstorm in the Socorro desert turned into a major disaster as students exited classes in MSEC to watch a rare hailstorm turn into baseball-size bombs pounding the NMT campus. Students gathered under the roof outside the front entrance of MSEC joking and collecting hailstones, only to later flee for cover from ice shrapnel being thrown up as huge hail-stones ricocheted off the side-walk. Students were trapped inside MSEC's entry doors while hail bombarded the inside floors through the shattered skylights. After the 30-minute storm, people rushed outside to fog and eerie silence that enveloped hundreds of cars with smashed windshields and damaged bodies. Luckily no one was seriously hurt, but repairs are still being done around campus as well as to personal vehicles and most of the roofs in Socorro. – *S. Delap*

December 2004 Sumatra Earthquake

On December 26, 2004, the largest earthquake to occur on Earth in over 40 years ruptured approximately 1200 km of a subduction zone plate boundary near Sumatra, Indonesia. This was also one of the largest natural disasters of the past 100 years, with the earth-quake and ensuing tsunami being responsible for the deaths of over 300,000 people in more than a dozen countries. Geophysics Pro-gram and EarthScope seismometers easily recorded this enormous event in New Mexico (where the oscillatory displacement of Earth's surface was about 1 cm(!), despite NMT being over 15,000 km from the epicenter. Geophysics Professor Rick Aster was in the spotlight in a report on global measurements of the earthquake in the January 13th, 2005 international edition of *The New York Times.* Geophysics Professors Susan Bilek and Aster are also among the co-authors of a feature article on the Sumatra Earthquake for the May 20, 2005 issue of *Science* magazine. – *R. Aster*

John Schlue Retiring in July 2005 After 30 Years in EES

Having graduated from UCLA in 1975, Dr. John Schlue served one year there as a postdoc while his wife Karen completed her studies. In 1976, John came to NMT to fill a faculty position vacated by Marshall Reiter, who had transferred to the Bureau. At that time the Geophysics group included Drs. Gerardo Gross, Allan Sanford, and Charles Holmes. Geoscience was housed in Workman Center with the Geophysics seismic array in the "pent-house" and observation tower (now demolished). Their up-to-date equipment included MEQ-800 digital recorders and an IBM 360/44 computer. Dr. Schlue ably served Geoscience as Chairman from 1987–1993 and has supervised seismic monitoring of the Carlsbad WIPP site since 1999. John will remain active in EES as he continues to collaborate with Drs. Aster, Bilek, and Sanford on work related to NM earthquakes. Karen retired as well from her job as Director of International Programs at NMT. They will stay in Socorro where John will continue to referee NM soccer tourna-ments. John considers himself "exceedingly fortunate to have been associated with people in this Earth science community." The feeling is mutual. Happy Retirement, John! – *P. Mills, A. Campbell*

Alumni News

David V. LeMone (BS Geology '55) writes:
"After NMT, received MS in Geology from University of Arizona in 1958 and PhD in Geology from Michigan State University in 1964. Have been a university professor for the past 43 years, and retired this year. Current activity is working on some papers for waste management and a group paper on extraterrestrial life systems."

Errol Watson (BS Geophysics '81) writes:
"Married, 2 girls ages 10 and 6. I have been with the DoD from 1985 after a 2-year stint with Schlumberger. One of my first projects was developing solutions for radar refraction corrections caused by temperature inversion at the Navy sea range and designing digital Kalman filters. Later on, I developed solutions and algorithm for Instantaneous Impact Prediction (IIP). Currently, I am technical team leader for DoD Test and Training Enabling Architecture (TENA) range integration instrumentation interface, lead object model developer for GPS, and team leader for Joint National Tactical Capability (JNTC) object model development."

David A. Caldwell (MS Geology '89) writes:
"Since 1997 my partners and I have been building a gold exploration company based out of Elko, Nevada. In 1999 we took the company public, and we are currently trading on the Toronto Ventures Exchange. Early in 2004 we purchased our first producing gold mine in Sinaloa, Mexico, and hired a Techie (Zach Hibdon, BS Geology 2004) to help us as the company grows towards becoming an intermediate producer."

Patrick Mattie (MS Geochemistry '96) writes:
"Patrick, who did his thesis with Kent Condie on lower crustal xenoliths in the Navajo Volcanic field, is currently a scientist at Sandia National Laboratories (SNL) in Albuquerque, New Mexico. SNL is a US Department of Energy National Laboratory providing science-based technologies that support national security. Patrick works in the Nuclear Risk & Technologies Division as a scientist specializing in the assessment of geologic disposal of high-level and low-level nuclear waste. He is a key member of a group evaluating the proposed repository at Yucca Mountain, Nevada, and is providing technical guidance to proposed geologic disposal projects in Taiwan and Egypt."

Internet Links

Find out more about topics covered in this newsletter by going to the following web pages.

National Cave and Karst Research Institute:
www2.nature.nps.gov/nckri/

SAHRA:
www.sahra.arizona.edu

CUAHSI:
www.cuahsi.org

Earthscope:
www.earthscope.org

IRIS/PASSCAL Instrument Center:
www.passcal.nmt.edu

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www.iris.edu

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EES and EarthScope

By Richard Aster, Professor of Geophysics

Geophysicists in the Earth and Environmental Science Department have been studying earthquakes for almost 50 years, beginning with the seminal work of Allan Sanford on earthquakes in New Mexico and the Socorro region. Beginning last year, the Department and New Mexico Tech assumed a historic role in the seismological component of the grandest continental geophysical and geological research project ever conceived.

2004 marked the first year of funding for the historic National Science Foundation EarthScope initiative. EarthScope is a multi-disciplinary Earth science effort to explore the geological structure, history, and processes of the North American continent on an unprecedented scale during the next decade and beyond. Key fundamental questions to be addressed by EarthScope science include how stress, strain, and faulting develop and are distributed at the continental scale; the structure, history, and processes of the continental crust and mantle; and the nature of coupling between mantle magmatism and convection with the brittle crust.

NMT is privileged to be playing major roles in the seismological component of EarthScope, USArray. In USArray, very large rolling arrays of thousands of satellite-telemetered seismic stations will be deployed across the nation to probe the structure of the continent from the shallow crust to deep within the mantle. At the largest scale, 400 broadband seismometers will operate simultaneously for approximately 18 months at a time in 1,500-by-1,000 km "footprints" using the planet's natural earthquake activity to produce new "CAT-scan-like" tomographic images of deep Earth structure. At smaller scales, focused deployments of seismometers will image targets of special scientific interest.

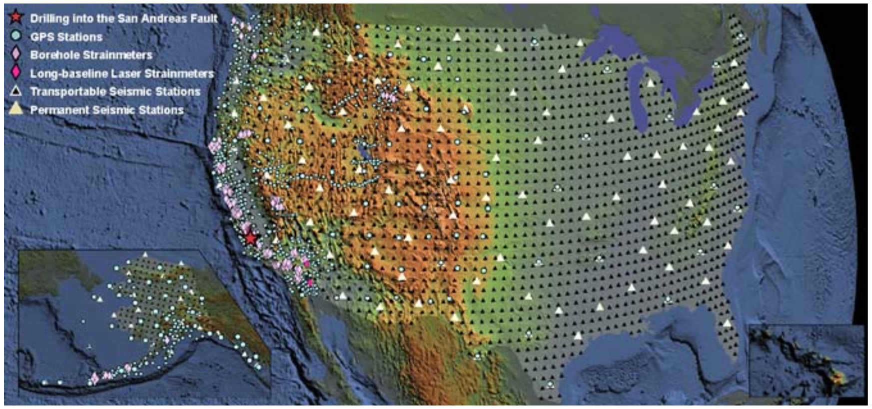
To support USArray staff, logistical, and visitor activities, NMT has constructed an on-campus 11,500-square-foot annex to the present Incorporated Research Institutions for Seismology (IRIS) Program for Array Seismic Studies of the Continental Lithosphere (PASSCAL) Instrument Center. The new building was completed in late 2004 (see photo on next page) and is occupied and

The newly-completed PASSCAL Instrument Center and EarthScope USArray Array Operations Facility at New Mexico Tech. This facility, with a present professional staff of 26, is responsible for staging and coordinating installation of and data retrieval from thousands of seismometers across the U.S. in coordination with the IRIS Consortium and EarthScope program through funding by the National Science Foundation. ***Image by Roger Renteria***

operational. The combined PASSCAL/EarthScope facility will be fully staffed with approximately 30 full-time employees by 2006. Students from EES and many other departments at NMT will continue to provide assistance in virtually all aspects of this operation. For example, NMT students in engineering and geophysics assisted in testing prototypes of EarthScope seismic stations on the NMT campus (see photo below).

The deployment of thousands of state-of-the-art geophysical instruments across the nation will offer not only dramatic scientific results, but also unique and far-ranging opportunities for associated Earth science education and outreach. NMT alumni interested in these activities, and/or in hosting a USArray seismic station, are welcome to contact Professor Rick Aster through the Department.

EarthScope prototype seismic stations being tested at New Mexico Tech



The National Science Foundation's EarthScope initiative will install thousands of seismic and other sensors across the nation and will bore a scientifically instrumented 3-km-deep drill hole on the San Andreas Fault near Parkfield, California. Coordination of the EarthScope seismological component, USArray, is being performed at the Instrument Center USArray Array Operations Facility by New Mexico Tech faculty, staff, and students in association with the IRIS Consortium. ***Image © EarthScope***

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