TECH TONICS
New Mexico Tech Department of Earth and Environmental Science
www.ees.nmt.edu
Alumni Newsletter
October 2010

NMT graduate student Shasta Marrero wields a rock saw while sampling a late Pleistocene basalt flow at Tabernacle Hill, Utah, for the CRONUS-Earth Project.

Collecting Cosmic Rays—The CRONUS-Earth Project

by Fred Phillips, Professor of Hydrology

For the past 5 years the EES Department has been the hub for cosmic rays in the US—or at least for their geological applications. The usefulness of cosmic rays for geology has been known since the 1950s, when they were found to make ^{14}C in the atmosphere. However, that was about all they contributed to geology until 1987,

INSIDE

when five papers were published measuring the production of five different isotopic species: ^{3}He, ^{10}Be, ^{21}Ne, ^{26}Al, and ^{36}Cl in rocks at the surface of the Earth. Cosmogenic ^{14}C produced in surface rocks was discovered a short while later. These are all produced by cosmic rays: high-energy particles that are produced by supernovae and constantly bombard the surface of the Earth. The reason that they took so long to be discovered was that cosmic rays produce them in amounts that are so tiny that the ability to measure them required the development of new, ultra-sensitive mass spectrometers. To illustrate how small the amounts are, consider the following: If you scraped 1 million tons of rock off the face of the Earth and extracted all of the ^{36}Cl in it, you would get about 1 milligram!

Since 1987 terrestrial cosmogenic nuclides have become a standard tool in the investigation of Earth-surface processes. They are commonly used to measure the age of features such as moraines, river terraces, and lava flows. They are also used to measure erosion rates over large spatial scales (river basins) and long time scales (million year). One of the most common applications is producing highly detailed chronologies of climate events in the recent geological past, such as correlating, between the northern and southern hemispheres, episodes of the last global deglaciation (between 18,000 and 11,000 years ago).

All of this requires a precise knowledge of cosmogenic nuclide production as a function of space and time. The primary cosmic ray particles are mostly protons, which interact strongly with the magnetic field of the Earth. They also interact with atoms in the atmosphere. This means that the flux of cosmic rays depends on geomagnetic latitude and elevation. It also varies with time, since the magnetic field has fluctuated throughout the history of the Earth. Furthermore, the rate at which the nuclides are produced has to be back-calculated by collecting samples of known age and measuring the nuclide content.

Production rates and corrections for these factors have been known for the past 20 years. However, as usage of the cosmogenic nuclides has increased, so has the awareness that these systematic constants and corrections were not yielding results reliable enough to compare the results from samples from anywhere on Earth. In response to this inadequate systematic framework, the National Science Foundation in 2005 funded the CRONUS-Earth Project (Cosmic-Ray Produced Nuclide Systematics on Earth Project). The

project involves investigators from 14 different universities and national laboratories across the US, with foreign investigators as collaborators. The Project runs from 2005 to 2011 at a total budget of over $5.8 million.

The project is headquartered at New Mexico Tech, with Professor of Hydrology **Fred Phillips** as the Principal Investigator. The overall project involves activities as diverse as flying neutron monitors in aircraft to measure the cosmic-ray flux and placing thin wafers of metal in front of neutron beams produced by giant particle accelerators to evaluate the nuclear reactions involved, but most of the work in the EES Department is geological and geochemical. It focuses on determining the production rate of ^{36}Cl, a nuclide that is particularly difficult to pin down because it is produced by several different nuclear reactions on several target elements.

On a typical Scottish day Fred Phillips chisels a sample loose from a moraine boulder in Corrie nan Arr, Western Highlands, Scotland.

The CRONUS-Earth Project established a series of "primary calibration sites" around the world. These are sites where the age of exposure of the rock can be very well established, where rates of surface erosion are low, and where the correct minerals are present

for the needed elements. These include a young lava flow in Utah, a deep shoreline notch cut by Lake Bonneville in Utah 14,700 years ago, bedrock exposed by retreating glaciers at the end of the last global glaciation in Scotland, moraines from the glacial maximum period in New England, lava flows in Hawaii, and moraines from the Quelccaya ice cap in Peru that were deposited at the end of the last glaciation. Since 2005, project participants have been traveling to these localities, participating in sampling parties, and processing the rocks brought back to extract and measure the ^{36}Cl.

In addition to Dr. Phillips, the principal project participants in the EES Department have been **Shasta Marrero**, a PhD student, **Michelle Hinz**, an MS student, and **Lisa Majkowski** (MS Geology, 2009), a project specialist. In addition, NMT mathematics professor **Brian Borchers** and one of his students, **Robert Aumer**, are working on crunching the numbers produced by the analytical laboratories.

NMT graduate student Michelle Hinz (left) and Jess Deemer of California State University repair a jeep tire with a ball point pen in the lava flows of the Big Island, Hawaii.

The field conditions have been challenging and varied. They include sawing off large masses of black basalt in temperatures hotter

than 100° F in Utah and Hawaii, freezing rain and swarms of midges in the Scottish highlands, and a blizzard on the first day at the Quelccaya ice cap. But they also included the chance to work in some of the most remote and beautiful places on the globe.

The real work comes after the samples are collected. They have to be ground up, sieved, leached, the correct minerals separated out (often the most tedious and difficult part), dissolved in mixed nitric and hydrofluoric acid, and the chlorine isolated by chemical precipitation. The chlorine must then be purified and shipped off to the Purdue Rare Isotope Measurement Laboratory for extreme high-sensitivity analysis using a tandem Van de Graaff particle accelerator. About two weeks of tedious and exacting laboratory work (more, if mineral separations are needed) are required for the processing of each batch of 12 samples.

After years of effort, the end of the project is approaching. With it, the payoff can be seen. The calibration data set produced for ^{10}Be from the global sampling is far better than the old one. Preliminary mathematical analysis of the ^{10}Be results has been completed. Prior to the project, it was expected that the best way to correct samples for the effects of the magnetic field would be data from the global neutron monitor network, maintained by physicists to evaluate the distribution of cosmic radiation. The CRONUS-Earth Project results have shown the neutron monitors do not accurately reflect the distribution of cosmogenic nuclide production. In fact, formulations developed to predict cosmic-radiation doses to airline pilots are more accurate for the nuclide production!

The ^{36}Cl calibration is much more complicated and requires more samples than that for ^{10}Be, so the analyses are still in progress. However, the preliminary indications are very encouraging that we will finally settle the long-standing uncertainties about ^{36}Cl production.

We are proud that New Mexico Tech can play a crucial role in solidly establishing this new method for understanding the history of the surface of the Earth.

For more information on the CRONUS-Earth Project, please visit http://www.physics.purdue.edu/cronus/

Richard C. Aster
Department Chairman
Professor of Geophysics

Note from the Chair

Dear Friends,

As you can see from the varied elements of this year's TECHtonics, we've had another notable year, including leading roles in a large set of world-class research projects (e.g., CRONUS-Earth), innovative teaching (Wilderness Skills), faculty development (a wide range of awards and a new professor in climatology, David Reusch), and, of course, a truly exceptional student population (see notes from Aaron Curtis, Jonathan MacCarthy, and Omar Marcillo). One measure of the department's strength is our successful recruitment of an exceptional group of talented undergraduate and graduate students this year (over 40 of them). It's always wonderful to hear from our alumni, and we want to hear from more of you! Please don't hesitate to contact me or Alumni Coordinator Andy Campbell should you be visiting Socorro, attending a national meeting, or wish to help out with a donation to one of our funds. (With no end in sight in the incredible shrinking New Mexico State budget saga, fundraising is increasingly critical to the continued successs of the department.) This will be my last *TECHtonics* note as chair; in July of next year I will be passing the reins to Gary Axen. Although being chair is often viewed as a thankless task, I want to note that it has been both a stimulating challenge and a great reward to serve our exceptional department in this way, and I know that Gary will be a tireless advocate and strong leader for Earth science at NMT in the future.

TECHtonics

Editor-in-Chief
Andrew R. Campbell

Assistant Editors
Richard C. Aster
Susan Delap Heath

Design, Layout, Printing
Susan Delap Heath

Distribution
Leigh Davidson
Shari Houston
Pat Valentine

B&W Logo Design
Robert Lowey (MS 1984)

TECHtonics
New Mexico Tech
Earth & Environmental Science
801 Leroy Place
Socorro, NM 87801
USA
(575) 835-5634
earthenv@nmt.edu

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New Wilderness Skills Course—ERTH 189

by Jeffrey Johnson, Assistant Professor of Geophysics

Much of Earth science is grounded in mapping, measurement, and collection of data in remote environments. During field work the outdoors is our office where we might contend with inclement weather, physical challenge, and logistical hurdles. The rewards justify the hard work. As geoscientists we have the opportunity to work in some of the most beautiful places on Earth and to tell the story about the processes that created them. Many of us turned to this profession because of the opportunities to combine science and outdoor experiences.

ERTH 189 students hiking toward Wheeler Peak

The EES Department introduced Wilderness Skills (ERTH 189) to its curriculum in Fall 2009 to teach the fundamentals of safe and enjoyable field experiences. In its inaugural year, seven students participated in weekly lectures focused on camping and First Aid skills, topographic map skills and orienteering, New Mexico geology, and rock climbing. The class, led by professors **Peter Mozley** and **Jeffrey Johnson**, met for two hours each Wednesday night for hands-on learning exercises and preparations for weekend trips.

Students participated in four trips including navigation exercises in the Magdalena Mountains, an ascent of Wheeler Peak (New Mexico's highest), roped rock climbing at The Box (near Socorro), and a river raft trip down the Rio Grande near Santa Fe. Both the Wheeler Peak trip and the river trip were overnight ventures. For the Rio Grande excursion, **Mike Timmons** of the New Mexico Bureau of Geology and Mineral Resources led the group down an ~25 mile wilderness stretch (i.e., no road access) replete with a section of class 2 and 2+ rapids.

ERTH 189 students tackle rapids on the Rio Grande

The class is currently continued in 2010. The nine registered students come from Earth sciences, physical sciences, and engineering and span freshman to graduate student. Although a few of the students have substantial outdoor experience, the class is tailored to include individuals who have never even camped overnight.

Regardless of skill level, however, all students are challenged physically and mentally. Climbing the highest mountain in New Mexico and paddling a rubber raft for two days through rapids is no easy task. But any field geoscientist will tell you that these experiences beat being cooped up in a stuffy office or dorm room!

Emphasis on Geological Carbon Sequestration in EES Department

by Peter Mozley, Associate Professor of Geology, and Andrew Campbell, Professor of Geology

A science and societal topic that is often in the news these days is CO_2 emissions to the atmosphere from human activities, and the role of CO_2 in climate change. Earth science plays a central role in the debate due to our understanding of past climates and our expertise in understanding the geology and geochemistry of potential subsurface storage sites.

A number of EES faculty and students are actively engaged in DOE-funded research and education related to geological sequestration of CO_2. Geological CO_2 sequestration involves capturing anthropogenic CO_2 before it is released to the atmosphere, and then injecting it into a subsurface reservoir.

Thomas Dewers, James Evans, and Utah State University and New Mexico Tech students (including Jason Heath and Graham Payne) examine an outcrop of the Entrada Formation, a proposed sequestration reservoir unit, in central Utah. Photo by Peter Mozley

Professor of Hydrology **Mark Person** is heading up a project to simulate, track, and evaluate on-going carbon sequestration pilot projects in Indiana and Illinois as well as trying to forecast the long-term consequences of large-scale CO_2 injection scenarios. Person's study is in collaboration with scientists at Princeton University, Los Alamos National Laboratory, Purdue University, and the Indiana Geological Survey.

Associate Professor of Geology **Peter Mozley** was recently awarded a grant to investigate the importance of features of the reservoir/seal (caprock) interface on the upward migration of CO_2 in the subsurface. His project is in collaboration with scientists at Utah State University and Sandia National Laboratories (including recent EES PhD **Jason Heath**). Mozley is also supervising the work of MS student **Graham Payne**, who is investigating the Carmel Formation in Utah as a possible seal for proposed sequestration sites in central Utah.

In addition to the above research, professors **Andrew Campbell** and **Peter Mozley** are heading up a geological carbon sequestration education and training program within the EES department. This program involves the development of several courses and a new undergraduate option in geological sequestration. The training program is in collaboration with the University of Utah and Texas A&M University.

EES Alumni Fund Donors

We would like to thank the following people who have generously donated to the EES Alumni Fund during the 2010 fiscal year (July 1, 2009–June 30, 2010)

DIAMOND $10,000 up

CORUNDUM $2000–$9,999

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Michael & Diane Camara
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EES Alumni Relations and Fundraising

by Andrew R. Campbell, Professor of Geology

It is always gratifying to hear news of our alumni, so I urge you to keep in contact and let us know what you are up to. Each issue we try to pass along as much of that information as we can fit, so you, too, can keep up with old friends. What won't fit in the newsletter is posted on our website: http://www.ees.nmt.edu/alumni/

I had the chance to see quite a few alumni last spring when we had **Dave Johnson**'s retirement party. Some of you came all the way from California or Texas to send Dave off in style. It was a chance for all to reminisce about Socorro experiences with old friends and to make new friends with students from different eras.

Others of you I hope to see at our annual reception at GSA in Denver this fall. Once again we are holding this jointly with the other "Rio Grande Universities" UNM, NMSU, and UTEP. It will be held **November 1, 2010**, in the Hyatt Regency Capitol Ballroom 4. We will also be holding our AGU reception in December. Details, when available, will be posted on our website.

This past year was a slow one for fundraising. But we thank those of you who were able to give. This year again, our fund raising focus is on the **Rob Bowman Graduate Fellowship Fund** for students in Hydrology. Rob was a driving force in our department in both academic and social pursuits. Over the years he worked with many students as a teacher and advisor. I hope that you will think of the ways in which Rob enriched your life, or the life of one of your friends, and help us honor him by building up a sizeable fund with which to assist future students. Our goal this year is to bring the fund up to the level that is needed to turn it into an endowed fund so that it will give back to the Hydrology group well into the future. We are also near the amount needed in the **Clay T. Smith Fund** to make that an endowment. So any contributions to either fund would get us closer to our goals.

Alumni Spotlights

James Gridley (MS Geophysics, 1989)

After an absence of almost twenty-five years, alumnus **James Gridley** will be returning to Socorro as the new Program Manager for the Incorporated Research Institutions for Seismology (IRIS) Program for Array Seismic Studies of the Continental Lithosphere (PASSCAL) Instrument Center, located on the NMT campus. Professor of Geophysics **Rick Aster** is the P.I. at IRIS PASSCAL. From the IRIS press release:

James is an applied geophysicist with a substantial background in geophysical instrumentation, measurements, analysis, and fieldwork. He was selected from a group of highly qualified candidates and succeeds **Jim Fowler** who is stepping down after 25 years of service. James begins his position on August 19, 2010. He will initially be based in the IRIS DC offices, but has committed to transfer with his family to New Mexico within the next two years.

James joins IRIS from BBN Technologies, a well-known consulting firm with offices in the Washington, DC area. While at BBN Technologies, as well as his previous position with the US Navy, he conducted classified research programs pertaining to seismic and other geophysical instrumentation for measurements and analyses of "exotic sources." Prior to that, he worked in the oil and gas industry for 11 years where he was responsible for several innovations in exploration research and development. He is familiar with IRIS programs and looks forward to moving into a more open environment and interacting with the academic research community.

In his career to date, James's primary focus has been on geophysical problems requiring a transformational vision of geophysical applications, with nontraditional aspects such as unique sources, new and innovative sensing systems, and challenging environmental conditions. His success has come from sound application of forward-looking science and innovative technology, and he brings

these talents to IRIS with a strong commitment to advancing future seismological research.

James has a BS from Northern Illinois, a MS from New Mexico Tech, and a PhD from the University of Texas at El Paso. He also has a law degree from University of Tulsa, related to his tenure as a private consultant in the oil and gas industry. James maintains relationships with the oil and gas industry, as well as with the Department of Defense and Department of Energy communities.

Alumni Awards

Bayani Cardenas (PhD Earth & Environmental Science-Hydrology, December 2006): **National Science Foundation CAREER Award, 2010,** for junior faculty who exemplify the role of teacher-scholars through outstanding research, excellent education, and the integration of education and research within the context of the mission of their organizations, and **Carolyn G. & G. Moses Knebel Distinguished Teaching Award at University of Texas-Austin, 2010,** which recognizes superior teaching to geology majors at all levels, selected via secret ballot submitted by sophomore geology students.

Roseanna M. Neupauer (PhD Earth & Environmental Science-Hydrology, December 2000): **Fellow, Geological Society of America, 2010**, and **John and Mercedes Peebles Innovation in Education Award at University of Colorado at Boulder, 2010**, which recognizes faculty of the college who have shown a unique commitment to students demonstrated through innovations in education.

Charlotte Rowe (BS Geology, 1981; PhD Geophysics, December 2000): **Los Alamos National Laboratory Star Award, 2010**. Awarded annually to women who go above and beyond in the performance of their job functions, who have achieved scientific or technical success, who make important contributions to the community, or who are stars in other ways.

Alumni News

Nathan Columbus (MS Hydrology, 1964, natcolumbus@hotmail.com) wrote in March 2010:

(Editor's note: Nathan's advisor was the late Mahdi Hantush, founder of the Hydrology Program at NMT.)

Several months prior to my graduation from NMT, the head of the ground water section at the Illinois State Water Survey, Bill Walton, came down (to NMT) and hired several future graduates, and I worked there in Champaign, Urbana, for almost 2 years.

Following that I returned to Israel where I joined the state corporation in charge of all water—TAHAL Consulting Engineers, Ltd.—as a hydrologist in the coastal aquifer. I worked at Tahal for 42 years during which I managed projects in ground water in the coastal plain of Israel, and later on in Northern Mexico's Sonora desert, as well as in Sao Paulo, Brazil, where we introduced at the time state-of-the-art technology in drilling deep (4,500 ft!) water wells into a deep confined artesian sandstone aquifer with high transmissivities and discharges of over 3,500 gpm. Following the termination of this project I was promoted to direct TAHAL branch in Brazil and later on deputy director and director of TAHAL in Latin America and the Caribbean, until my final retirement at the end of 2007.

I have since been active as a private consultant advising in Israel for TAHAL, MEKOROT (The National State Water Company), other companies in Israel related to water resources, and governments including Antigua, Barbuda, Argentina, and the British Virgin Islands. My main areas of consulting are ground water and water resources development including artificial recharge of ground water, reuse of effluents through purification by means of artificial recharge after oxidation lagoons treatment, and the exploitation of water resources on an integrated basis.

I am a member of the Association of Engineers and Architects of Israel, a registered Professional Civil Engineer in Israel, and the co–founder of ABAS—the Brazilian Association of Ground Water in 1977. In 1987 I was elected a Fellow of the American Society of Civil Engineers (ASCE), and in 2009 I became a Gold Life member of the ASCE and was honored at the Annual Outstanding Projects and Leaders Awards in Washington D.C. in April of 2009, for my long-time contribution and commitment to the society and the profession in publishing and peer review of articles.

Barry L. Keith (BS Geology, December 1972, barry@etechenv.com) wrote in August 2010:

Barry and wife, Dawna, live in Midland, Texas. Barry is with Etech Environmental & Safety Solutions, Inc. Dawna works for an independent oil company.

Charlotte Rowe (BS Geology, 1981; PhD Geophysics, December 2000, carowe@cybermesa.com) wrote in June 2010:

I was used by *Popular Science Magazine* as their expert du jour to answer a reader's question in the March 2010 issue. So my fifteen minutes of fame amounted to being embarrassingly misquoted and having my comments misrepresented by the magazine's reporter, who was quizzing me about why we don't just dispose of all our nuclear waste by throwing it down a volcano. At least they got the gist of what I said, which could be summed up as "Ooooo, bad idea."

Timothy Callahan (MS Geochemistry, 1995; PhD Hydrology, December 2001, callahant@cofc.edu) wrote in January 2010:

Dr. Tim Callahan has been promoted to director of the MS in Environmental Studies program at the College of Charleston. Dr. Callahan joined the college in 2001 after earning his PhD in Earth and Environmental Sciences (with Dissertation in Hydrology) at New Mexico Tech, one of the top five US graduate programs in hydrology. While studying for the PhD, he was employed as a Research Assistant at Los Alamos National Laboratory in New Mexico and worked on site assessment of ground water resources at Yucca Mountain, Nevada. Dr. Callahan has been granted over $400,000 in external funding for local, state, and national-level research projects. He has published several papers on ground water pollution, the hydrology of Carolina Bays and other freshwater depression wetlands, and watershed hydrology in the Coastal Plain region.

Huade Guan (PhD Hydrology, December 2005, nmtguan@yahoo.com) wrote in August 2010:

I finished my PhD study from NMT in 2005. After a year in a postdoctoral position at University of Texas at San Antonio, I moved to Flinders University in 2007 as a lecturer (similar to assistant professor in US). Flinders University is one of three universities in Adelaide, the capital city of South Australia.

Adelaide is a coastal city, sitting next to small mountain ranges where I continue my research on mountain block recharge. Flinders University is located on a hill, where you can easily see the ocean and CBD. I am now working at the School of Environment, teaching surface water hydrology, and also working with Australia's National Centre for Groundwater Research and Training. Sometimes, we have international visitors. I met **Remke van Dam** (former hydrology postdoc at NMT). He gave a seminar on his subsurface imaging at Flinders a few days ago.

Adelaide is very good for family life. There are beaches, hills, kangaroos, and all sorts of wine. We enjoy almost everything here, as we did at NMT. Above is a picture of the family on a trip to Kangaroo Island. This is a good place to visit and live. Keep in touch.

Jaron Andrews (MS Hydrology, December 2009, Andrews.Jaron @gmail.com) wrote in August 2010:

All in all, things are going really good out here. My wife, Jolene, and I moved out to Virginia almost as soon as I turned in my thesis and started working for the federal government. We are so thankful that we have such good jobs during these tough economic times. I work for the Army Geospatial Center, which is part of the US Army Corps of Engineers. The division I work for helps military well drillers find water overseas and maintain a database of water resources around the world. I use GIS software all the time and write technical reports about water resources in other countries. My wife works for the EPA reviewing pesticide toxicity and warning labels and is still finishing up her degree.

We have great work environments and like living here other than the expensive homes, the traffic, and the trees—LOL! I never really cherished the beauty of New Mexico and the vast distances you could see until I came here to Virginia, and all I could see were trees and more trees. My wife and I miss New Mexico a lot and hope that everyone is enjoying it back there.

EES Department News

New Mexico Tech is now a member of the Western North America InSAR (WInSAR) Consortium of universities and research laboratories to facilitate collaboration in, and advancement of, Earth science research using radar remote sensing. For more information, visit http://winsar.unavco.org or talk with our Institutional Representative, Associate Research Professor of Geophysics **Mark Murray**.

Professor of Hydrology **Jan Hendrickx** hosted a scintillometry workshop at the Sevilleta National Wildlife Refuge October 12–15, 2009. A parallel inter-comparison experiment ran from October 9–24. Thirty participants from 6 countries attended. Sponsors were the Consortium of Universities for the Advancement of Hydrologic Science, Inc. (CUAHSI) and the US Army Research Office. Pictured above are NMT PhD candidate **Laura Rosales-Lagarde** and former NMT postdoc and workshop instructor **Jan Kleissl** from University of California, San Diego. Photo courtesy of Wenguang Zhao of University of Idaho.

Associate Professor of Geophysics **Susan Bilek** was elected to the Incorporated Research Institutions for Seismology (IRIS) Board of Directors for a 3-year term. The Board, composed of nine representatives from over 50 IRIS Member Institutions, appoints committee members that oversee individual programs and meets several times a year to review policies and priorities and to set budgets. IRIS programs based at NMT are the PASSCAL Instrument Center and the EarthScope USArray Array Operations Center.

Professor of Hydrology **Mark Person** was named co-editor of the journal *Geofluids* effective January 2011.

Associate Professor of Caves and Karst **Penny Boston** is an astrobiologist on a team of scientists from NMT and Cal Tech's Jet Propulsion Lab (JPL) that are building the New Mexico Tech Extrasolar Spectroscopic Survey Instrument (NESSI) at the Magdalena Ridge Observatory. Primarily funded by a NASA EPSCoR grant, this ground-based instrument will examine the atmospheric chemistry of distant planets and infer whether a biosphere is conducive to the existence of life. NESSI will examine exoplanets mostly within 100 light years of our solar system and should be operational sometime in 2011. More details can be found at http://www.nmt.edu/news/3676-new-exoplanet-research-paper-shines-light-on-tech-project

The 8.8 earthquake that occurred in Chile on February 27, 2010, kept professor **Rick Aster** busy along with the IRIS PASSCAL Instrument Center of which he is the Principal Investigator. PASSCAL quickly deployed 60 seismic stations in the area working with other US universities and several countries. "This is really an historic event, because earthquakes of this size occur a few times a century," Rick said. "We hope to see ongoing changes in the properties of the Earth as the system readjusts to this huge earthquake. This earthquake is also highly relevant to learning about the physics and damaging effects of giant earthquakes that will occur in the US in the future." More details can be found at http://www.nmt.edu/news/all-news/303-featured/3755-tech-scientists-deploy-seismic-sensor-array-in-chile

Rick was also interviewed by local TV stations and other media outlets regarding the Chile earthquake. He was also quoted in a news article in *Nature* about upper limits on earthquake magnitudes. Referring to the largest earthquake every recorded, the 9.5 Chile earthquake in 1960, Rick said, "…you wouldn't get one much bigger. Faults are only so big and so strong." To illustrate this, Rick added up all the seismic energy released during the 20th century plus the Sumatra quake of 2004 and imagined all this energy unleashed in a single event. The resultant magnitude of this event would be equal to a magnitude 9.95 earthquake. "You're just not going to get a 10," he said.

At Commencement 2010, NMT graduated over 363 students, including 5 bachelor's degrees, 14 master's degrees, and 1 PhD degree from the EES department. Pictured on the next page are (L to R)

Professor of Hydrology **Jan Hendrickx**, **Emily Engle** (MS Geology August 2009), **Jeremiah Morse** (MS Hydrology 2010), and Professors of Hydrology **Fred Phillips** and **John Wilson**.

During Commencement 2010, Professor of Geophysics **Rick Aster** received the Distinguished Research Award. Vice President of Research **Van Romero** described Rick's many achievements, including how Rick has become an internationally renowned expert in geophysics through his leading edge research and outreach efforts. Romero said that Rick is a leader in a number of ambitious projects to image the Earth's interior that are advancing the field of seismology by generations, and he is leading the global effort to explore and image the deep interior structure of the Earth. Rick's most visible achievement was bringing the IRIS PASSCAL Instrument Center to Socorro in 1998. "The community of Earth scientists—and especially our friends at Stanford and Columbia—were shocked when this little upstart university in New Mexico won the bid and became the new home of the IRIS PASSCAL Instrument Center," Romero said. Rick is also pioneering the study of colliding icebergs and ocean storms using seismology, which is at the forefront of a new class of geophysics—climate seismology—that is

adding to the scientific debate about global climate change. More details can be found at http://www.nmt.edu/news/3827-aster-arendt-take-top-faculty-honors

Also during Commencement 2010, Associate Professor of Geology and Dean of Graduate Studies **Dave Johnson** received the Graduate Student Association's Appreciation Award. PhD Candidate **Shasta Marrero** (MS Hydrology, 2009), past president of GSA, presented Dave with the award saying, "In between his regular duties as graduate dean and professor, Dave has offered invaluable advice to numerous graduate students as well as the GSA as a whole for many years. We will miss Dave when he retires this summer, but his contributions will live on."

Yes, **Dave Johnson** has retired, and the EES department conspired with the NMT Graduate Office to give him quite a sendoff. Festivities began at 3 pm on May 13, 2010, led by emcee **Lisa Majkowski** (MS Geology, 2009). A large crowd filled the front patio of MSEC including alumni and VIPs. Professor of Geology **Andy Campbell** delivered the "keynote speech" which reflected on Dave's many years at NMT including some colorful anecdotes.

Debbie Wallace of the Graduate Office presented Dave with a Wacom computer pen and tablet from members of EES and the Graduate Office. **Leigh Davidson** led the "student revenge" portion of the presentation where Dave was presented with parodies of "essential" field equipment and given one hour to perform a field-mapping exercise on a multi-layered gelatinous confection prepared by Professor of Hydrology **Fred Phillips**. Dave enjoyed eating this concoction more than accurately mapping it, so we moved on to the final part of the program with the "Evolution of Dave" movie prepared by Lisa and Associate Professor of Caves and Karst **Penny Boston.** More details and videos are here: http://www.ees.nmt.edu/DeptNewsSpring2010.html#retires

Associate Professor of Geology **Gary Axen** will be one of two invited speakers at the first annual GSA Structural Geology and Tectonics Division symposium, which will commemorate the Division's 30th anniversary. This event will be Tuesday, November 2, at 1:30 pm at the national meeting in Denver and will kick off an annual SG&T symposium series. Gary's talk is titled "The weak-fault paradox and slip on low-angle normal faults."

Like some other large-slip faults, such as the San Andreas fault, slip on low-angle normal faults is not well explained by current fault-mechanical theory. Gary, NMT students **Amy Luther** (PhD candidate, pictured above) and **Niranjan Khalsa** (undergraduate), and co-principal investigator **Jane Selverstone** (UNM) are studying two low-angle normal faults in southern California using combined structural and petrologic methods. In the picture above, the arrow is pointing at the nearly horizontal fault at the Whipple detachment in southern California.

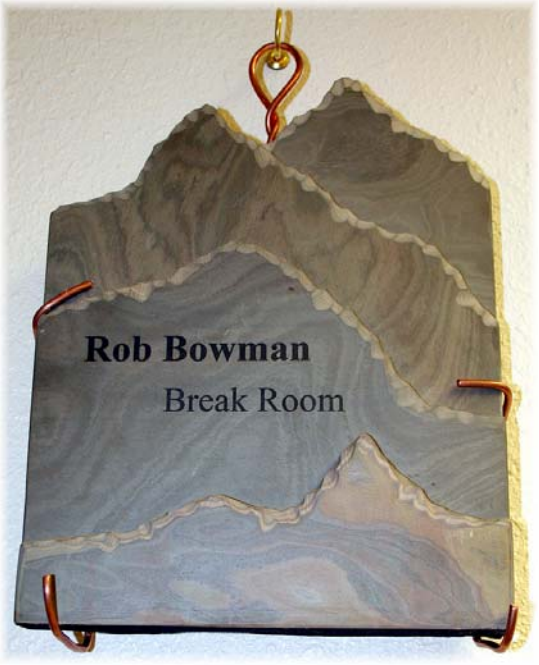
Associate Professor of Caves and Karst **Penny Boston** received the National Speleological Society's Science Award in August 2010 "in recognition of a lifetime of contributions to the science of speleology."

Assistant Professor of Geophysics **Jeffrey Johnson** was featured on National Geographic Channel's TV show *National Geographic Amazing* with his footage of Santiaguito Volcano in Guatamala.

EES Administrative Services Coordinator **Barbara Fazio** retired in June 2010, and **Pat Valentine** (pictured at left), who replaced Colleen Villanova in 2009, has moved into Barbara's position. Pat is no stranger to NMT, having worked previously in Payroll, the Post Office, and several businesses in Socorro including Holiday Inn Express, NAPA, and Sears. She also used to manage a 40-acre ranch with sheep, cattle, horses, and pigs. She manages people well, too, and keeps the office well-stocked with peanuts and M&M'S®. Receptionist **Leigh Davidson** moved into Pat's position, but Leigh's position is not being filled due to budget cuts at NMT. MS student **Shari Houston** (BS Earth Science, 2008) is helping out part time in the office.

The **Rob Bowman Break Room** (formerly the student lounge on the second floor of MSEC) was officially dedicated on September 15, 2010, to honor Rob for his broad inspiration and efforts in making department improvements for students. When Rob was EES Chair and MS student **Shari Houston** (BS Earth Science, 2008) was undergraduate representative to the department, she and Rob discussed what students needed to improve their stay at NMT. The student break room was high on the list. Shari says that Rob wanted to make the room a "home away from home." Rob put Shari in charge of the remodel, and with the help of **Brad Christensen** (MS Geophysics, 2010), **Matt Earthman** (MS Geochemistry, July 2010), **Natalie Thomas-Earthman** (BS Management, 2009), and EES lab tech **Andrew Phillips**, the transformation was stunning.

During the dedication (pictured above), EES Chair **Rick Aster** gave a tribute to Rob, told the crowd the history of the break room remodel, and hung a carved stone plaque at the entrance. PhD candidate **Hugo Gutierrez** presented a sketch he had made of Rob to display in the room. NMT President **Dan Lopez** and VP **Peter Gerity** said a few words in memory of Rob. Rob's wife, **Karen Bailey-Bowman,** was also present, and we all enjoyed sharing this moment with her.

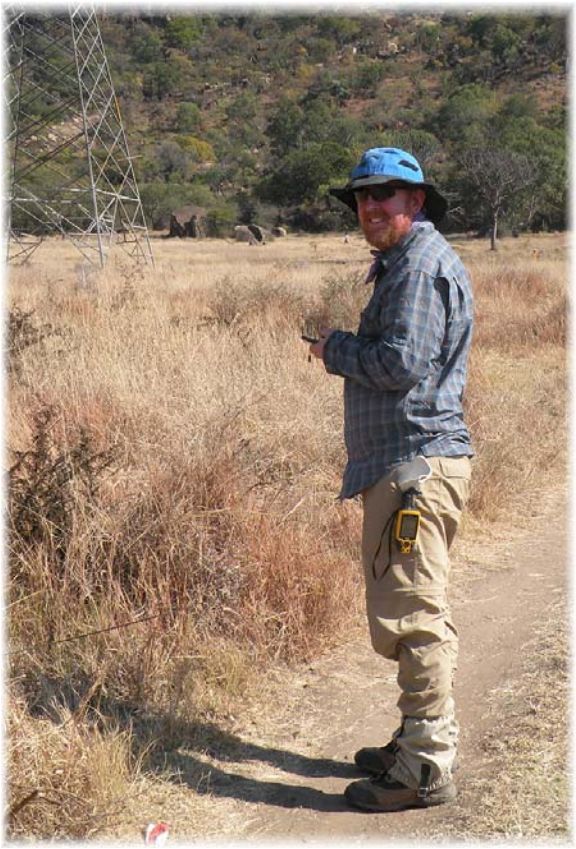


You can watch a video of the event at http://www.ees.nmt.edu/DeptNewsFall2010.html#Bowman

Faculty Spotlight

David B. Reusch

Associate Research Professor of Climatology



The dust has barely settled from my mid-August arrival in Socorro after a nearly 11-year association with Penn State and State College as PhD student, then soft-money researcher. I will shortly be EES' first Associate Research Professor of Climatology. My wife and I actually transitioned via Greensboro, North Carolina, where we spent this year's winter and spring as a postdoc and visiting faculty, respectively, in the North Carolina Agricultural and Technical State University physics department. Needless to say, we're seeing a broad range of climates this year!

My background is a mix of computer science skills from undergrad (University of Maine) and an MSc at the University of New Hampshire plus a broad range of geoscience from another UNH MSc in the Earth Sciences (featuring Antarctic ice cores) and my Penn State Geosciences PhD (2003). All this education has produced a wide range of interests in the geosciences, though these run deepest in the area of understanding Earth's complex climate system. Married to a geophysicist/seismologist (Angela—better known as Mouse, now working as a staff scientist/data specialist up

the hill at IRIS PASSCAL), it's been hard to not pick up a few things about that field as well over the years!

My primary research interests revolve around polar climates, understanding recent variability, and predicting how this may change in the future, although climate just about anywhere can also get my attention. There are abundant research questions in this polar climatology, and even more when I bring in the intersections of the atmosphere, cryosphere, and oceans! My research projects have been bipolar with work on problems in both Antarctica and Greenland, two regions with potentially high societal impact in a warming world. Melting ice sheets help to drive sea level rise, a thorny problem affecting low-lying tropical islands and heavily populated coastal regions around the world. Current projects focus on the climatology and meteorology of West Antarctica, including studying surface temperatures, atmospheric circulation, and satellite records of clouds. I am also investigating whether credible long-term records of sea ice can be reconstructed using ice core data. A potential forthcoming project will look at Antarctic surface melt occurrence, past and future. (Yes, it does melt down there sometimes!)

One of the attractions of EES is the chance to be the only climatologist in the department. This sort of thing can typically go one of two ways: You end up isolated because nobody knows what you do and their work doesn't overlap, or you become a valuable interdisciplinary resource bringing new, societally relevant research interests and teaching materials to the department. The vibe I get so far from the many enthusiastic EES faculty I've been meeting is that this will be an exciting, rewarding position! I'm definitely looking forward to developing new collaborations in climate science with my new EES colleagues.

In the few weeks since arriving, we've been able to start getting back into one of our favorite pursuits—recreational road biking—and we have high hopes for getting out to see more of the local sights. The desert Southwest is certainly a change for this "born and bred" New Englander, but the beautiful scenery and friendly people are already helping to ease the transition. I have to admit, though, we already miss the abundant minor league baseball on the East Coast. Fortunately the Isotopes are only an hour away!

Student Spotlights

Aaron Curtis, MS Student in Geology

Aaron Curtis surveying Tricicle Chamber in Warren Cave, Antarctica. Compasses were rendered useless by magnetite in the lava, so a transit was required for surveying. Photo by Nial Peters

For many years now, I've been involved in projects mapping limestone caves and disentangling microclimate processes for fun and science. The Mount Erebus Volcano Observatory at NMT has given me the opportunity to apply those techniques to investigate a truly awesome and unique phenomenon: the Fumarolic Ice Caves (FICs) and Fumarolic Ice Towers (FITs) of Erebus Volcano, Antarctica.

Around two hundred FITs and FIC are scattered around the summit caldera. FICs are networks of tunnels, some several hundred meters long, melted into the bottom of the snowpack by heating from below and containing a huge variety of spectacular ice crystal formations and volcanic gasses. They are related to towers rising up to 30 m from the surface of the snow which form

when the water-rich volcanic gasses are released into Erebus' -35°F atmosphere.

I spent five weeks on the volcano from November 2009 to January 2010 gathering data and samples to answer questions regarding the processes that form FITs and FICs, what they can tell us about the plumbing of the volcano, and whether these environments harbor microbial life. With the help of the Erebus team and field assistant Nial Peters, I placed 22 dataloggers in the caves that will record microclimate parameters for at least a year. We retrieved seven cores from FIT walls to check for magmatic water and hydrothermal components by hydrogen and oxygen isotope analysis using NMT's new laser cavity ringdown mass spectrometer, as well as several gas samples for analysis on a gas chromatograph. Survey and mapping was also a success: we produced complete three-dimensional maps of five caves.

Working on Erebus was an incredible experience, and I'm looking forward to returning. Tasks for the 2010–2011 field season will include downloading dataloggers, re-mapping several of the caves to look for geometric changes, and completing a catalogue of all cave entrance locations on the volcano. The project will be featured in the BBC's upcoming documentary, *Frozen Planet*.

Jonathan MacCarthy, PhD Candidate in Geophysics

In 2006 I began my PhD studies at NMT with professor **Rick Aster**. I study joint inversions of mantle P velocity and density, but my main project was deploying half of the CREST stations and doing body wave tomography for P and S velocity.

The CREST project (Colorado Rockies Experiment and Seismic Transects) is a multi-institutional and cross-disciplinary collaboration between geoscientists across the country to study the crust and mantle of the Colorado Rocky Mountains region. The project, principally funded by the National Science Foundation's Continental Dynamics Program, is designed to answer questions about how mantle processes beneath the Colorado Rocky Mountains have influenced their tectonic history and contributed to formation of one of America's most iconic landscapes. A key aspect of this work is to understand when and why changes in buoyancy forces and dynamic mantle convection forces have occurred during the past 60 million years (post-Laramide), as well as to understand the re-

gion's present mantle dynamics. CREST was partially motivated by the prior discovery of a poorly resolved low velocity mantle seismic anomaly underlying the central Colorado Rockies—the Aspen Anomaly—that suggested active mantle processes were occurring.

The first CREST seismic station (completed in the rain) being celebrated by NMT geophysics students Julien Chaput (left) and Jon MacCarthy (plaid shirt), and IRIS PASSCAL scientists Shane Ingate (right) and Michael Johnson (purple shirt)

In order to "see" deep beneath the mountains, a group from NMT's Geophysics Program led by my advisor, **Rick Aster**, teamed up with the University of Wyoming and NMT's IRIS PASSCAL Instrument Center to deploy 59 seismic stations across western Colorado from mid 2008 to late 2009. We used these and other nearby stations from the EarthScope program to produce one of the densest seismic arrays ever deployed at this scale to "listen" for earthquakes happening across the globe. Using recordings of the energy from far away earthquakes, we apply state-of-the-art seismic CAT-scan-like methods to learn about the current thermal and chemical structure of the mantle beneath Colorado from its seismic structure. These images, which show an unprecedented and unexpected amount of mantle complexity are key to understanding the com-

plex dynamics of the Southern Rocky Mountains region and suggest that appreciable recent uplift has occurred in the past 5 million years. Additional components of CREST include geomorphological, geological (in partnership with **Shari Kelley** and **Matt Heizler** from the New Mexico Bureau of Geology and Mineral Resources), and geochronological studies done in association with other students and scientists from Los Alamos National Laboratory, Montana State, University of New Mexico, University of Colorado, Mesa State, Penn State, Colorado College, and the University of Arizona.

Omar Marcillo, PhD Candidate in Geophysics

Omar Marcillo and MS student Rebecca Johnson retrieving instrumentation from a station located 5 km southeast of the summit of Kilauea volcano

I work with professor **Jeffrey Johnson** in the Infrasound Laboratory here at New Mexico Tech. My main research focuses on the generation and propagation of infrasound in the atmosphere.

Infrasound is acoustic energy with frequencies below the human audible spectrum, and can travel hundreds of kilometers with low atmospheric attenuation. Infrasound is used as a monitoring tool for phenomena with atmospheric responses such as volcanic eruptions, ocean swells, tornadoes, and nuclear and chemical explosions. For example, "listening" to infrasound in volcanic environ-

ments can provide information about the precise location of active vents and the magnitude of explosions.

Special microphones that are sensitive to low frequencies are required to record infrasound. In our laboratory, we have designed and built a line of infrasound microphones based on a piezoelectric transducer. A couple of years ago, we built our first batch, the A-version microphones, and already we are now testing the G-version microphone.

We have deployed our sensors on volcanoes in South, Central, and North America, as well as Antarctica. Research groups at NMT and other universities use our sensors for different studies. Here at NMT, a group at the Physics Department uses our sensors to study infrasound produced by lighting. At Michigan Tech, another group uses our sensors to study volcanoes and snow avalanches.

During the summer of 2008, our group installed a 3-sensor infrasound network around the Kilauea volcano in Hawaii to study one of the active vents in the Halema'uma'u pit crater. We recorded continuous infrasound for 48 hours. Using this data, we were able to estimate the conditions of the atmosphere.

In the summer of 2010, we returned to Kilauea volcano and deployed 50 of our newest sensors around the Kilauea crater summit for approximately two weeks. We are currently analyzing this dataset to recover a detailed 4D image of the atmosphere around the volcano. The goal of this research is to provide critical information for the study and monitoring of volcanic ash and gas plumes.

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