2015 PROFILE

Inside

GEOLOGY GEOPHYSICS

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FROM THE DEPARTMENT HEAD

Season's Greetings! Winter is finally upon the Gem City. Over the thirty odd years that I have been here the winters have gotten to be less and less severe. Gone are those multiple weeks of -20° F or lower. It seems that Laramie weather comes out a winner from global warming.

Weather figured prominently in our failed attempt to host an alumni event for those of you living in the Houston area this past October. Heavy rains led us to cancel the event at the last minute. Our plan now is to try to have the event again later this spring, but no specific dates have been set as yet. We will send out invites once plans are firmed up.

The present energy bust has had impacts on the department, and I am sure, with some of our alumni. Support for student research and scholarships from our corporate sponsors have slowed. It is hard to know when things might turn around in the industry. Our hope is that our alumni are spared the worse brunt of industry cut backs. Despite the downturn in the energy industry, we still had a successful Rocky Mountain Rendezvous job fair with about 250 students from across the country attending and 14 companies interviewing. Next year we might hold the event in Denver for the first time, in conjunction with the national meeting of the Geological Society of America.

Luckily the faculty have proven to be resourceful and surprisingly successful at securing grant funding to support graduate students. In addition, our alumni donors have continued to support department activities, including scholarships. As a result we are not hurting too badly by the retreat of industry support. Nonetheless, if you have any influence within the companies, I hope you will help keep our department visible for when hiring levels return.

Lastly, thank you all for your continued support which we always appreciate, but especially during these tight times. The State has, again, announced cut backs in University funding, so now, more than ever, we make use of your charity to maintain the department. On behalf of the entire department, I thank you for your support.

Oh yes … have a happy New Year! ❖

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www.uwyo.edu/geolgeophys/alumni/update.html

UW RESEARCHERS DISCOVER SEDIMENT SIZE DOES MATTER IN HIGH-ELEVATION EROSION RATES

When it comes to sediment in the High Sierra, size does matter, according to two University of Wyoming researchers.

For the past four summers, **Cliff Riebe**, a UW associate professor in the Department of Geology and Geophysics, and **Claire Lukens**, a UW doctoral student majoring in geology, have studied sediment in Inyo Creek, in California's High Serra.

The two found that cold, steep, high-elevation slopes with less vegetation produce coarser and larger sediment than low-elevation, gentle slopes. This finding quantifies how sediment production varies with topography and suggests that variations in climate, topography and weathering rates may shape the evolution of mountain landscapes by influencing sediment size.

Riebe is lead author of a paper, titled "Climate and Topography Control the Size and Flux of Sediment Produced on Steep Mountain Slopes," that was published online Nov. 16 in the *Proceedings of the National Academy of Sciences* (PNAS). Lukens, from Seattle, Wash., is co-author. The journal is one of the world's most prestigious multidisciplinary scientific serials, with coverage spanning the biological, physical and social sciences.

Both the size and flux of sediment from slopes can influence channel incision, making sediment production and erosion central to the interplay of climate and tectonics in landscape evolution, Riebe says.

"Rivers need tools to cut into their beds," Riebe says. "Water alone can't do the job. And the bigger the sediment is, the easier it is for the river to carve into the landscape. So, when it comes to sediment, it turns out that size really does matter."

"Sediment can be as large as boulders at higher elevations and as fine as sand at lower elevations on the landscape," Lukens adds. "We know this is true from our analyses of sediment in the stream. In effect, we are using geochemistry to interrogate stream sediment about where it comes from and how fast it is eroding."

woman in a mountain meadow with many large rocky outcroppingsErosion rates are commonly measured using cosmogenic nuclides, which serve as tracers of erosion because they accumulate in minerals in the uppermost few meters of rock and soil during the exhumation to the landscape surface. For example, the isotope beryllium 10 is produced from

Doctoral student Claire Lukens, a co-author of a paper in PNAS, samples sediment from hill slopes in Inyo Creek. Hill slope samples were used to determine the intensity of chemical weathering across the landscape, which may help explain why the size of eroded sediment varies from place to place. (Marlie Malone Photo).

oxygen by nuclear reactions in quartz as the mineral rises to the surface.

Riebe and Lukens combined this technique with another sediment tracing tool called detrital thermochronometry, which identifies the elevations of hill slopes where sediment was produced by weathering of underlying bedrock. The two used computer simulations to determine the statistical significance of their findings.

"This is the first time these tools have been combined in this way," Lukens says.

For a long time, geologists have been able to quantify how fast sediment is eroding from landscapes. Until this UW research, there has been no complementary method to quantify how the size distribution of sediment particles varies across slopes where the sediment is produced from bedrock by weathering and erosion.

Riebe says their sediment findings could be used for the same purpose in Wyoming's Wind River Range.

"The landscapes in Wyoming also would be an interesting place to ask questions, and see how different or similar they are to the Sierras," Lukens says.

Leonard Sklar, a professor of earth and climate sciences at San Francisco State University, and David Shuster, an associate professor of earth and planetary science at the University of California-Berkeley, were other co-authors of the paper. ❖

UW RESEARCHERS ADVANCE UNDERSTANDING OF MOUNTAIN WATERSHEDS

University of Wyoming geoscientists have discovered that the underground water-holding capacity of mountain watersheds may be controlled by stresses in the earth's crust. The results, which may have important ramifications for understanding streamflow and aquifer systems in upland watersheds, appeared Oct. 30 in *Science*, one of the world's leading scientific journals.

The scientists conducted geophysical surveys to estimate the volume of open pore space in the subsurface at three sites around the country. Computer models of the state of stress at those sites showed remarkable agreement with the geophysical images. The surprising implication, says **Steve Holbrook**, a UW professor in the Department of Geology and Geophysics, is that scientists may be able to predict the distribution of pore space in the subsurface of mountain watersheds by looking at the state of stress in the earth's crust. That state of stress controls where subsurface fractures are opening up — which, in turn, creates the space for water to reside in the subsurface, he says.

"I think this paper is important because it proposes a new theoretical framework for understanding the large-scale porosity structure of watersheds, especially in areas with crystalline bedrock (such as granite or gneiss)," Holbrook says. "This has important implications for understanding runoff in streams, aquifer recharge and the long-term evolution of landscapes."

James St. Clair, a UW doctoral student, is lead author of the paper, titled "Geophysical Imaging Reveals Topographic Stress Control of Bedrock Weathering." Holbrook, **Cliff Riebe,** a UW associate professor of geology and geophysics; and **Brad Carr**, a research scientist in geology and geophysics; are co-authors of the paper.

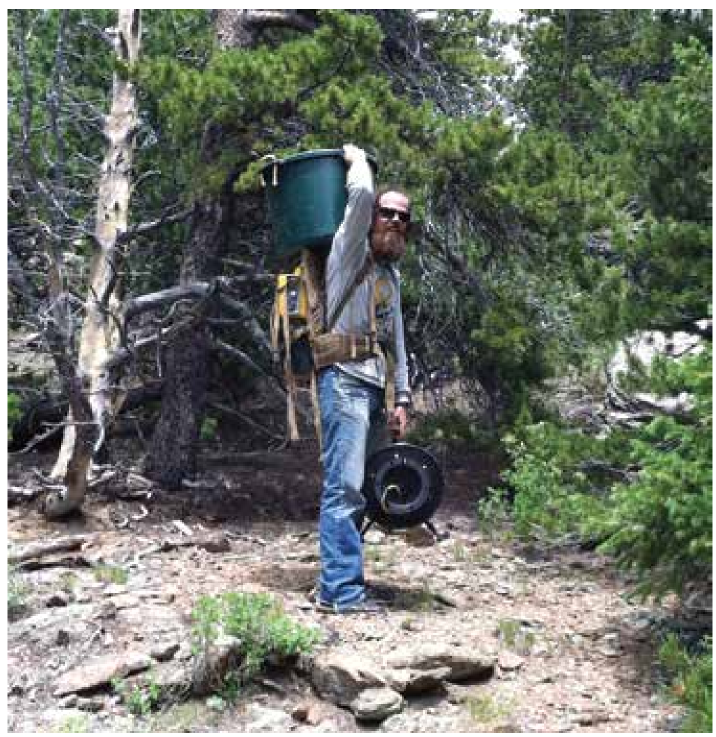
Researchers from MIT, UCLA, the University of Hawaii, Johns Hopkins University, Duke University and the Colorado School of Mines also contributed.

Weathered bedrock and soil together make up the life-sustaining layer at Earth's surface commonly referred to as the "critical zone." Two of the three study sites were part of the national Critical Zone Observatory (CZO) network — Gordon Gulch in Boulder Creek, Colo., and Calhoun Experimental Forest, S.C. The third study site was Pond Branch, Md., near Baltimore.

"The paper provides a new framework for understanding the distribution of permeable fractures in the critical zone (CZ). This is important because it provides a means for predicting where in the subsurface there are likely to be fractures capable of storing water and/or supporting groundwater flow," St. Clair says. "Since we cannot see into the subsurface without drilling holes or performing geophysical surveys, our results provide the means for making first order predictions about CZ structure as a function of the local topography and knowledge (or an estimate) of the regional tectonic stress conditions."

The research included a combination of geophysical imaging of the subsurface — conducted by UW's Wyoming Center for Environmental Hydrology and Geophysics (WyCEHG) — and numerical models of the stress distribution in the subsurface, work that was done at MIT and the University of Hawaii, Holbrook says.

The team performed seismic refraction and electrical resistivity surveys to determine the depth of bedrock at the three sites, which were chosen due to varying topography and ambient tectonic stress. At the two East Coast sites,



James St. Clair, a doctoral student, is the lead author on a Science paper that discovers the distribution of porosity in the subsurface of mountain watersheds can be determined by looking at the state of stress in the earth's crust. (Steve Holbrook Photo)

the bedrock showed a surprising mirror-image relationship to topography; at the Rocky Mountain site, the bedrock was parallel to topography. In each case, the stress models successfully predicted the bedrock pattern.

"We found a remarkable agreement between the predictions of those stress models and the images of the porosity in the subsurface with geophysics at a large scale, at the landscape scale," Holbrook says. "It's the first time anyone's really looked at this at the landscape scale."

St. Clair says he was fortunate to work with a talented group of scientists with an extensive amount of research experience. He adds the experience improved his ability to work with a group of people with diverse backgrounds and improve his writing.

"Our results may be important to hydrologists, geomorphologists and geophysicists," St. Clair says. "Hydrologists, because it provides a means for identifying where water may be stored or where the flow rates are likely to be high; geomorphologists, because our results predict where chemical weathering rates are likely to be accelerated due to increased fluid flow along permeable fractures; and geophysicists, because it points out the potential influence of shallow stress fields on the seismic response of the CZ."

Despite the discovery, Holbrook says there is still much work to be done to test this model in different environments.

"But, now we have a theoretical framework to guide that work, as well as unique geophysical data to suggest that the hypothesis has merit," he says.

The work was supported by the National Science Foundation's (NSF) EPSCoR program, the U.S. Army Research Office and the NSF Critical Zone Observatory Network. ❖

UW RESEARCHERS: HISTORY SHOWS MORE BIG WILDFIRES LIKELY AS CLIMATE WARMS

The history of wildfires over the past 2,000 years in a northern Colorado mountain range indicates that large fires will continue to increase as a result of a warming climate, according to a new study led by a University of Wyoming doctoral student.

"What our research shows is that even modest regional warming trends, like we are currently experiencing, can cause exceptionally large areas in the Rockies to be burned by wildfires," says John Calder, a Ph.D. candidate in UW's Program in Ecology and the Department of Geology and Geophysics.

Doctoral candidate John Calder holds sediment cores taken from Seven Lakes in the Mount Zirkel Wilderness Area of northern Colorado. Calder and his colleagues examined charcoal deposits in 12 lakes in and near the wilderness area, finding that wildfires burned large portions of that area during a documented spike in temperatures in North America starting about 1,000 years ago. (Bryan Shuman Photo)

The findings were published in the *Proceedings of the National Academy of Sciences*, a major scientific journal. The paper, "Medieval warming initiated exceptionally large wildfire outbreaks in the Rocky Mountains," is co-written by UW researchers Calder, Dusty Parker, Cody Stopka and Bryan Shuman, along with Gonzalo Jimenez-Moreno of the University of Granada in Spain.

Calder and his colleagues examined charcoal deposits in 12 lakes in and near the Mount Zirkel Wilderness of northern Colorado, finding that wildfires burned large portions of that area during a documented spike in temperatures in North America starting about 1,000 years ago. That period, known as the Medieval Warm Period (MWP), lasted about 300 years, when temperatures rose just under 1 degree Fahrenheit.

Temperature increases over the past few decades have been comparable to those of the MWP, resulting in some of the largest wildfires in U.S. history. Since the mid-1980s, beginning with the large fires in Yellowstone National Park in 1988, there has been an increase in the frequency of large wildfires in the American West.

If the warming trend continues as projected, the fires of recent years could be just the start of more extensive and devastating blazes, the researchers say.

The study examined how often large areas burned in the past 2,000 years. It found that the only time when fires burned substantially more area than in the 20th century was during the MWP.

"When we look back in time, we only see evidence of large areas burning one time in the last 2,000 years," Calder says. "This suggests that large wildfires of the magnitude we have recently seen used to be very infrequent."

The researchers estimate that 83 percent of the 385-square-mile study area burned at the beginning of the MWP, when the climate warmed 0.9 degrees. That represented an increase of more than 250 percent, compared to the 20th century.

By comparison, the average increase in temperature in the Rocky Mountain region since 2000 has been about 1.25 degrees higher than during the 20th century.

"Corresponding to those higher temperatures, 12 percent of our study area burned in the large Zirkel Complex fire in 2002," Calder says. "Our data indicate man hiking in mountain meadowthat, in the Medieval Warm Period, fires were either much larger, or large fires similar to the Zirkel Complex fire burned in that same wilderness area once every decade or two when the temperatures warmed by 0.9 degrees Fahrenheit."

The Medieval fires would be unusual almost anywhere in the Rockies.

"Using Yellowstone fire history as a baseline for comparison, our minimum estimate of 50 percent of (Mount Zirkel) sites burned within a century at the beginning of the MWP exceeds any century-scale estimate of Yellowstone burning for the past 750 years," the scientists wrote. Over the century that led up to and included the massive 1988 fires, only about 30 percent of Yellowstone burned.

"The large increase in the number of sites burned by fires (during the MWP) highlights the risk that large portions of individual landscapes may burn as climates continue to warm today," the researchers concluded. ❖

UW'S WYCEHG RESEARCHERS TRAVEL THE COUNTRY TO ASSESS CRITICAL ZONE OBSERVATORIES

For the price of gas, food and lodging, University of Wyoming hydrology and geology researchers have traveled across the country the past two summers to examine Critical Zone Observatories (CZOs), projects that have created significant use of UW's hydrology instrumentation and built important collaborations with scientists from major universities.

These sites encompass watersheds where groups of scientists can collaborate and work across disciplines to develop a more complete understanding of the biological, chemical, geological, hydrological and physical processes that operate in the Critical Zone, which is defined as the region from treetop to bedrock that supports most life on Earth.

Matthew Elliot, a undergraduate student from Jackson, swings a sledgehammer in easter Oregon while acquiring seismic refraction data. The refraction data will provide estimates of porosity in the subsurface. (Brady Flinchum Photo)

"I think of it (Critical Zone) as the breathing skin of planet Earth. It's like this membrane tens of meters thick," says Steve Holbrook, a UW professor in the Department of Geology and Geophysics, and co-director of the Wyoming Center for Hydrology and Geophysics (WyCEHG). "Across this membrane is the transfer of things impactful for life — water, chemical compounds and nutrients."

To understand the complex cycles of carbon, nitrogen, oxygen and water that run through these Critical Zones, research has to be conducted in an integrated way, Holbrook says. This includes using the combined expertise of atmospheric scientists, botanists, geologists, geophysicists, hydrologists and soil scientists.

Six years ago, the National Science Foundation (NSF) established a network of five CZOs stretching from Puerto Rico to California. Today, there are 10, ranging in size from "as small as a little catchment or as long as a watershed," Holbrook says.

During the past year, WyCEHG's geophysics team has worked at six of the 10 CZOs. These include Calhoun, S.C.; Boulder Creek, Colo.; Reynolds Creek, Idaho; Eel River, Northern California; Southern Sierra, Southern California; and Jemez-Catalina in Arizona and N.M. This summer, Holbrook had 13 UW students available to accompany him to these sites.

"I think we're the only group that's worked at this many sites," he says. "We get to collaborate with great scientists from other universities. It's been a huge benefit and source of pride for us."

The UW group has worked with researchers from nearly 15 universities, including Duke, Johns Hopkins, MIT and UC-Berkeley. These universities have secured grants to conduct the field research. In exchange, Holbrook, through the WyCEHG grant, pays for his student crew and the equipment.

"We ask that they (universities) pay for expenses," which includes gas, food and lodging, he says.

During these stops, Holbrook and a number of UW graduate and undergraduate students are able to collect large amounts of data quickly with WYCEHG equipment, which includes seismic, electrical resistivity, electromagnetic induction, ground penetrating radar and magnetic instrumentation.

"All people working at CZOs are coming to the realization that, in order to succeed in their scientific goals, they needed to dig deeper," Holbrook explains. "Most of them didn't have a geophysicist. They were missing that part. We provided a unique component that they needed. Most universities don't have a lot of the equipment we have."

During visits to multiple Critical Zones, Holbrook says the most interesting discovery was that, at watershed sites that were compared, a new physical insight into what controls the distribution of the porosity in the subsurface was realized. He says the work, conducted with researchers from MIT, is expected to be published in a well-known science journal this fall.

"It's been a fantastic experience for our graduate and undergraduate students," Holbrook says. "I'm proud of this team. At every one of these sites we go to and work at, when we pack up our site to leave, they (other university researchers) say you have a terrific team.

"This provides lots of benefit to UW. It's putting us in a position to write more grant proposals and secure future funding once the WYCEHG grant expires." ❖

UW, INDUSTRY COLLABORATE ON TIGHT OIL RESEARCH

Growing Oil and gas producers in Wyoming's Powder River Basin are expected to gain insights that will improve the precision and effectiveness of their operations as a result of a cooperative research project with the University of Wyoming.

A team of researchers from UW's Department of Geology and Geophysics, as well as the School of Energy Resources, has joined forces with Helis Oil & Gas Co. and Devon Energy for the second phase of the Cretaceous Tight Oil Consortium. The group aims to find the best ways to tap unconventional oil reservoirs in what has been one of Wyoming's busiest oil fields this decade.

"We're excited to be working with these independent companies to help figure out ways to be more efficient in developing existing fields," says **Erin Campbell-Stone**, senior lecturer in the Department of Geology and Geophysics. "We hope the result will be more production, which means more revenue for the state and the university, along with an increased general understanding of Wyoming geology."

The first phase of the research, which began in 2012, focused on the stratigraphy of the tight sandstone of the Frontier Formation in the Powder River Basin. Using core and outcrop analysis, as well as well log interpretation, former graduate student **Rebekah Rhodes** provided a clearer picture

Former graduate student Virginia Marcon loads unconventional reservoir rock into a gold crucible in a UW Department of Geology and Geophysics laboratory, part of a research project analyzing geochemical reactions of the rock in the Powder River Basin with chemicals used in hydraulic fracturing. (UW Photo)

of the subsurface that will help companies better model and more efficiently extract oil from deep reservoirs.

The second phase, which is just getting started, involves analyzing the interaction of hydraulic fracturing fluids with the minerals of the Frontier Formation. Hydraulic fracturing is a technique used to extract oil and gas from rock by injecting high-pressure mixtures of water, sand or gravel and chemicals.

"We're looking at how the fluids react with the Frontier Formation," says **John Kaszuba**, associate professor in the Department of Geology and Geophysics and the School of Energy Resources. "That should provide companies with information about what treatments to use downhole to maximize production."

Using core samples from the Frontier Formation and chemicals used in hydraulic fracturing, UW researchers over the next two years will duplicate underground temperature and pressure levels in the laboratory to analyze the geochemical reactions. The research could provide insights into chemicals to use or avoid during hydraulic fracturing.

In some cases, it's possible that certain chemicals stimulate reactions that reduce the flow of oil and gas prematurely, Kaszuba says.

"If minerals behave badly, they can plug wells," he says. "If there are steep production drop-offs in certain wells, they could be mineral-related."

The other UW faculty member helping lead the research is **Brandon McElroy**, assistant professor in the Department of Geology and Geophysics. He says, "The combination of stratigraphic and geochemical research could substantially improve well completions in the Frontier Formation and other similar reservoirs."

Officials with Helis Oil & Gas and Devon Energy say the consortium's research is valuable to the companies.

"This initiative is important on many levels — for industry, the academic community and the state," says Paul Lawless of Helis. "Everyone wins when efficiencies are improved through better technology and a better understanding of what stimulates production most effectively. We applaud the university for this innovative research and look forward to continuing our engagement with the consortium."

"These types of industry and academic collaborations help Devon achieve best-in-class performance by utilizing cutting-edge technology to drive better business decisions," says Dale Fritz, Devon's vice president of reservoir technology and optimization. "We're pleased to have a role in this valuable project."

In addition to the expected benefits for oil and gas producers and for the state, McElroy notes that the students involved in the research are gaining valuable knowledge directly applicable to Wyoming industry — and scientific skills that will help them in their careers, wherever they go. Involved in the project are three graduate students and two undergraduate students, along with McElroy, Kaszuba and Campbell-Stone.

"The students are learning how to identify and solve fundamental scientific problems," Kaszuba says. "Looking at and understanding fundamental problems, and then applying their scientific findings to applied problems, is at the heart of what we want them to learn at the university." ❖

UW'S WYCEHG RECEIVES MAJOR RESEARCH INSTRUMENTATION AWARD

The University of Wyoming will soon receive a new piece of equipment that will more accurately measure aquifer levels in the ground.

UW's Wyoming Center for Environmental Hydrology and Geophysics (WyCEHG) received a two-year $408,000 National Science Foundation (NSF) Major Instrument Research Award for a borehole nuclear magnetic resonance (NMR) instrument. This geophysical tool, also referred to as a Javelin, can be deployed into boreholes and analyze how much water is in the aquifer and how easy or difficult it might be to extract that water. The instrument works on the same physical principles as medical MRI imaging.

"This is a relatively new technology for water," says **Andrew Parsekian**, an assistant professor in UW's Department of Geology and Geophysics as well as the Department of Civil and Architectural Engineering. "The technology has been used for decades in the oil exploration industry. However, it has only emerged for use in hydrogeology within the past few years. This borehole NMR instrument will be the only one owned and operated by an academic institution in the United States at the current time."

Bill Gern, UW's vice president for research and economic development, says the piece of equipment "fills out the WyCEHG instrumentation suite for examination of subsurface hydrology. This will help UW become one of the top five universities in subsurface hydrology in the United States."

Parsekian says the instrument will be used to visualize where water is stored underground; what the geometric properties of aquifers are; and how water changes over time. Initially, the instrument is scheduled to make measurements on projects related to fractured-rock aquifers; permafrost thaw, which releases carbons into the atmosphere; weathering in the Critical Zone (everything between the ground surface and the bottom of the aquifer, including plants, soil and rocks); and return flow from irrigation and macro-pore flow into tropical soils.

The instrument, which can log boreholes as small as two inches in diameter, will first be used for a water return flow study in Dubois, where a contained catchment is located, Parsekian says. The Javelin also will be used in the Laramie Range during the winter to measure WyCEHG wells located there, he adds.

"Making these measurements with traditional tools can be really difficult and hard to get high spatial resolution," Parsekian explains. "Using this geological tool that can measure where the water is and how fast it moves is exciting."

By emitting a series of radio-frequency pulses and recording the returning signal, the Javelin measures the NMR response of groundwater in the sensitive zone, much like an MRI scanner measures the NMR response of tissues in the body, according to the Vista Clara Inc. website. Vista Clara, a company based in Mukilteo, Wash., manufactures the instrument.

"A hydrologist wants to know how much water is in the aquifer; how easily can you extract it; or how fast does it move away from your area," Parsekian says.

While the NSF award was officially granted July 15, the borehole NMR instrument will take at least six months to build, Parsekian says. ❖

INTERACTIVE SANDBOX A BIG HIT WITH UW GEOLOGICAL MUSEUM VISITORS

Who wants to play in a sandbox while standing in the shadows of some of the world's best-preserved dinosaur collections? Nearly everyone who enters the University of Wyoming Geological Museum, that's who.

It's no ordinary sandbox, though. It's called an Augmented Reality Sandbox (ARS), an interactive exhibit that teaches such concepts as topography, watersheds, ecosystems and much more using kinetic sand and innovative software technology. UW is among only a handful of institutions in the United States that offers an ARS experience to visitors. Several research centers developed the ARS with funding from the National Science Foundation.

At the UW Geological Museum, the sandbox is not only being used as an interactive public display, it also serves as a tool for some of the geology classes to explain topographical maps and watersheds.

"Future plans are to create an ARS module where the water function acts as groundwater and will have a water-table baseline that can be 'drilled into' by lowering elevation of sand," says **Laura Vietti**, museum and collections manager.

It's fun, too. Vietti says the sandbox is easily one of the museum's most popular exhibits. Both children and adults usually spend more time there than at the other exhibits.

"The typical response we hear is 'this is so cool!', or 'wow, how does this work,'" Vietti says. "My favorite comment was by a student visiting the museum with a class group, who said 'I can't wait to come back this weekend with my friends to play with this again.'"

One of the reasons the ARS is such a hit with visitors is because it is one of the museum's truly interactive exhibits. Vietti says several other museum exhibits allow visitors to touch fossils or take a guess at identifying some.

"One of our goals is to offer more interactive exhibits at the museum," she says.

A demonstration of the sandbox can be found at http://youtu.be/F2VjtWB9CLw. ❖

INCOMING UW GEOLOGY GRAD STUDENT RECEIVES NSF FELLOWSHIP

An opportunity to research how geology affects the growth of the world's biggest trees attracted **Lindsay Arvin** to graduate studies in the University of Wyoming's Department of Geology and Geophysics.

She will conduct such research as a recipient of the prestigious National Science Foundation (NSF) Graduate Research Fellowship, one of 2,000 individuals — three at UW — selected from among 16,500 applicants in 2015. The fellowships support graduate studies for students "based on their demonstrated potential for significant achievements in science and engineering," according to an NSF media release.

Arvin, originally from Chicago, recently received her bachelor's degree in geological sciences from the University of Southern California (USC). She will begin her UW studies this fall under Associate Professor **Cliff Riebe**, with plans to earn a Ph.D. in geology in five years.

Riebe has been researching how bedrock influences forests and landscape evolution in California's Sierra Nevada Mountains. He and his students, last year, published groundbreaking research concluding that bedrock composition is just as important as climate in influencing the growth of plants, including the Giant Sequoia, the largest trees on Earth.

"Now, the challenge is getting at what's behind all the patterns they recognized," Arvin says. "Trying to find out what makes the conditions right for those trees to grow is just inherently interesting."

Arvin learned about Riebe's research from one of her USC professors and decided to apply for graduate school in

Incoming UW graduate student Lindsay Arvin, here on a geology field course in Spain, received a National Science Foundation Graduate Research Fellowship.

Undergraduate senior Annette Estella Hein received a Goldwater Scholarship. (UW Photo)

UW's Department of Geology and Geophysics. Competition for the department's graduate openings is tight, and Riebe says Arvin stood out because of her enthusiasm for the work his group has been doing.

"Lindsay has the interest and background in all the right areas to really help us advance the research we have been doing," Riebe says. "I was thrilled that she had decided to come work with us, and that was before I heard about the NSF fellowship."

Having visited UW in February, Arvin says she's looking forward to getting started this fall. The NSF fellowship will give her "a lot of freedom and opportunity" in Riebe's research program, she says.

"As an undergraduate without any experience in the project yet, I wasn't expecting it at all," Arvin says of the fellowship. "It's very exciting." ❖

UW STUDENT FROM CASPER RECEIVES GOLDWATER SCHOLARSHIP

Undergraduate student **Annette Estella Hein**, a home-schooled student who became interested in science while hiking and experiencing nature in the geologic formations around Casper, has been awarded a Goldwater Scholarship.

It is a nationally competitive, merit-based award given to only 300 college juniors and seniors each year who show exceptional promise for a Ph.D. degree in a STEM (science, technology, engineering and mathematics) research career path. Among the most prestigious undergraduate awards given in the sciences, the scholarship covers tuition, fees, books and room and board up to a maximum of $7,500 per year.

Hein is the only student to have been awarded the honor in Wyoming this year. Since 2006, only four Goldwater awards have gone to UW students.

"Annette has earned such national recognition for her promise as a geoscience scholar," says Hein's mentor, **Andrew Parsekian**, assistant professor in the UW Department of Geology and Geophysics. "Even at this early stage in her career, she's already immersed herself in geophysics research. I look forward to seeing what new discoveries she will make in the future."

She was home-schooled by her parents, who grow a lot of their own food and sell produce at a farmers' market in Casper. Her curiosity about rocks and the origins of geologic formations attracted her to geology, and her interest in the field was strengthened when she took science courses at Casper College before transferring to UW.

"The best part of my education has been outside of classes, getting to do some independent work in geology and working as a research assistant engaged with the subject," she says.

Hein says she plans to go to graduate school, and eventually would like to work as a geologist in industry. She is particularly interested in water resources.

"That's a big issue right now. You hear about droughts in California, where they are being told what they need to do with their water. I feel that may be coming to more states in the next several decades," she says. "So we really need to understand what we can do to use resources to maintain a high standard of living." ❖

UW RESEARCHERS CONTRIBUTE TO CONTINENT-BUILDING DISCOVERY

An international research team, including University of Wyoming Professor of Geophysics **Steve Holbrook** and current and former UW graduate students, has revealed information about how continents were generated on Earth more than 2.5 billion years ago — and how those processes have continued within the last 70 million years to profoundly affect the planet's life and climate.

Published online in *Nature Geoscience*, the study details how relatively recent geologic events — volcanic activity 10 million years ago in what is now Panama and Costa Rica — hold the secrets of the extreme continent-building that took place billions of years earlier.

The discovery provides new understanding about the formation of the Earth's continental crust — masses of buoyant rock rich with silica, a compound that combines silicon and oxygen.

"Without continental crust, the whole planet would be covered with water," says lead author Esteban Gazel, an assistant professor of geology with Virginia Tech University's College of Science, in a Virginia Tech media release. "Most terrestrial planets in the solar system have basaltic crusts similar to Earth's oceanic crust, but the continental masses — areas of buoyant, thick silicic crust — are a unique characteristic of Earth."

Joining Gazel in the research were Holbrook, former UW Ph.D. student **Erik Everson** and current Ph.D. student **Jorden Hayes** of Richland Center, Wis. Hayes is the second author of the paper.

"The generation of continental crust has been a long-standing mystery in Earth science," Holbrook says. "Our study represents the first time that the signatures of continental crust — both geophysical and geochemical — have been observed in an active volcanic arc."

"This research is really exciting because crustal genesis has systematic implications for nearly every other period of Earth's history," Hayes says. "As a geophysicist, it is highly rewarding to see our geophysical interpretation corroborate with geochemical observations."

The continental mass of the planet formed in the Archaean Eon, about 2.5 billion years ago. The Earth was three times hotter, volcanic activity was considerably higher, and life was probably very limited.

Many scientists think that all of the planet's continental crust was generated during this time in Earth's history, and the material continually recycles through collisions of tectonic plates on the outermost shell of the planet.

But the new research shows "juvenile" continental crust has been produced throughout Earth's history.

"Whether the Earth has been recycling all of its continental crust has always been the big mystery," Gazel said. "We were able to use the formation of the Central America land bridge as a natural laboratory to understand how continents formed, and we discovered while the massive production of continental crust that took place during the Archaean is no longer the norm, there are exceptions that produce 'juvenile' continental crust."

The researchers used geochemical and geophysical data to reconstruct the evolution of what is now Costa Rica and Panama, which was generated when two oceanic plates collided and melted iron- and magnesium-rich oceanic crust over the past 70 million years, Gazel says. Melting of the oceanic crust originally produced what today are the Galapagos Islands, reproducing Achaean-like conditions to provide the "missing ingredient" in the generation of continental crust.

The researchers discovered the geochemical signature of erupted lavas reached continental crust-like composition about 10 million years ago. They tested the material and observed seismic waves traveling through the crust at velocities closer to the ones observed in continental crust worldwide.

Additionally, the researchers provided a global survey of volcanoes from oceanic arcs, where two oceanic plates interact. The western Aleutian Islands and the Iwo Jima segment of the Izu-Bonin islands are some other examples of juvenile continental crust that has formed recently, the researchers say.

The study raises questions about the global impact newly generated continental crust has had over the ages, and the role it has played in the evolution of not just continents, but life itself.

For example, the formation of the Central American land bridge resulted in the closure of the seaway, which changed how the ocean circulated, separated marine species, and had a powerful impact on the planet's climate.

"We've revealed a major unknown in the evolution of our planet," Gazel says.

Other researchers involved in the project include the GEOMAR Helmholtz Center for Ocean Research in Kiel, Germany, the Lamont-Doherty Earth Observatory of

Columbia University, Simon Fraser University in Canada, Rutgers University and the University of South Carolina. ❖

UW RESEARCHER NAMED SENIOR SCIENTIST FOR NOAA CRUISE NEAR PUERTO RICO IN APRIL

Over the years, **Michael Cheadle** has been a team member on a number of research ships that have explored the floor of the world's vast oceans. The University of Wyoming faculty member has recently taken a step up, being named senior scientist for an expedition in the waters off the coast of Puerto Rico this past April.

Cheadle, a UW associate professor in the Department of Geology and Geophysics, was one of two senior scientists (serving as the geologist) that headed a "telepresence" research cruise aboard the *Okeanos Explorer*, a National Oceanographic and Atmospheric Administration (NOAA) ship. The Okeanos Explorer, dubbed "America's Ship for Ocean Exploration," is the only federally funded U.S. ship assigned to systematically explore the world's largely unknown oceans for the purpose of discovery and the advancement of knowledge.

"Overall, we were looking at the biology, especially deep sea corals, and understanding the geology for hazard assessment purposes, including evidence for large earthquakes and possible resulting tsunamis," says Cheadle, who just returned from sabbatical. "Puerto Rico is on a large transform fault between the Caribbean and North American tectonic plates. This is part of the same fault system that generated the large earthquake in Haiti a few years ago. The idea of the cruise is to map the sea floor in an effort to better understand the earthquake potential around Puerto Rico, a U.S. territory."

On Jan. 12, 2010, an earthquake, with a magnitude of 7.0, hit approximately 16 miles west of Port-au-Prince, Haiti's capital. Two weeks later, at least 52 aftershocks measuring 4.5 or greater were recorded. An estimated 3 million people were affected by the disaster, with death toll estimates ranging from 100,000 to 160,000.

Cheadle and the other senior scientist — Andrea Quattrini, a biologist from the U.S. Geological Survey — were on board to direct and coordinate input from 30 or more scientists, stationed on land, who drove the science.

The Puerto Rico Trench, the Muertos Trough, the Mona Channel, the Virgin Island Trough and local seamounts and canyons will be explored. This expedition will feature some of the deepest remotely operated vehicle (ROV) dives (down to 6,000 meters below sea level) ever conducted in the regions,

Associate Professor Mike Cheadle, was one of two senior scientists in charge of the *Okeanos Explorer*, a ship that explored the biology of the waters around Puerto Rico and the geology for hazard assessment purposes in April and May. (UW Photo)

and will collect critical deep-water environmental information that will improve ecosystem understanding and inform federal and local resource managers.

"Mike was chosen for his expert knowledge of geophysics and seafloor plate tectonics, coupled with his previous experience working with telepresence-enabled ocean exploration and his participation in the Ocean Exploration Trust exploration workshops," says Lt. Brian Kennedy, expedition coordinator with NOAA's Office of Ocean Exploration and Research.

"This was very much a telepresence cruise, with the ship beaming the whole event live to the outside world via their (NOAA) website," Cheadle says of planned educational outreach. "The whole idea was to make it like the (land) rovers on Mars program."

Scientists used the *Okeanos Explorer's* cutting-edge technology and custom-built collaboration tools to stay in constant contact with the ship, and guide operations from shore. During the expedition, NOAA sent out "exploration alerts" or brief emails on especially interesting seafloor exploration dives and to share exciting discoveries in real time, according to Sarah Graddy, a public affairs specialist with NOAA.

Currently, more than 100 people receive these exploration alerts, including journalists from National Geographic, the New York Times, Wired, Science, Scientific American, CNN, CBS and the Smithsonian Institute.

"Outreach is very much a part of (NOAA's) mandate," Cheadle says. ❖

UW RESEARCHER CONTRIBUTES TO BETTER UNDERSTANDING OF EARTH'S GEOLOGICAL EVOLUTION

Changing conditions on the Earth's surface can have a major influence on the composition of its overwhelmingly more massive interior.

Ken Sims, a University of Wyoming professor of geology and geophysics, has helped make that evolutionary and geological process more accurate and understandable — using new instruments to more precisely measure a uranium element carbon dating ratio of 238U/235U.

"The timing and the extent that the material is put back down into the Earth's mantle is addressed by this ratio in a unique way that was not possible a decade ago," Sims says. "Our ability to make these isotopic measurements is so greatly enhanced."

Sims is a co-writer of a paper, titled "The Terrestrial Uranium Isotope Cycle." The paper appeared in the Jan. 15 issue of *Nature*, an international weekly journal of science that publishes the finest peer-reviewed research in all fields of science and technology.

"This paper is important because the Earth is dynamic. It is always differentiating and remixing. We see that in plate tectonics," Sims says. "Thorium and uranium are particularly important chemical elements for understanding these processes. We've used them for many years to understand the time scales of these processes."

Sims and the paper's other writers — including Tim Elliott, a longtime colleague from the Bristol Isotope Group at the University of Bristol, United Kingdom — took a number of rock samples, collected from around the globe during the past 30 years, and used them to make very precise measurements with uranium isotopes.

These more precise measurements are obtainable because today's mass spectrometers are so much better and can measure out a few more decimal points than previous versions of the instrument were capable of, Sims says.

"We can now routinely measure sub per million variations of the 238U/235U isotope ratio, which we used to think was constant in the earth at 137.88," he adds.

Mass spectrometry is an analytical chemistry technique that helps identify the isotopes of chemical elements present in a sample.

"With these measurements, we are able to put a better understanding on the recycling of material back into the Earth's mantle — the area between the Earth's core and its crust — back into the deep earth," Sims says. "That's because these uranium isotopes are perturbed or changed by the surface processes that are happening. So, we can look at rocks that are coming back out of the mantle and understand this recycling as well as this differentiating of the early Earth."

With the use of a submersible called Alvin, many of the rock samples were collected on mid-ocean ridges like the East Pacific. Mid-ocean ridges are underwater mountain systems that are composed of various mountain ranges.

These ridges typically have a mountain valley — known as a rift — that runs along its spine and is formed by plate tectonics. Mid-ocean ridges are geologically active, with new magma constantly emerging on the ocean floor and spreading away from the ridge. The crystallized magma forms a new crust of basalt, known as mid-ocean ridge basalt or MORB.

Ocean island basalts (OIBs), from places like Hawaii, Iceland, Canary Islands (La Palma), Azores (Pico and Sao Miguel islands), Society Islands and Samoa, also were analyzed. OIBs are basaltic rocks found on many volcanic islands away from tectonic plate boundaries typically associated with hot spots.

Other co-writers of the paper include researchers from the University of Bristol; Durham University, United Kingdom; the Institute of Geochemistry and Petrology at ETH Zurich, Switzerland; and Rhode Island University.

"Because of this system, we understand the evolution of Earth better," Sims says. "That is, we can address how material that has been oxidized on the surface of the Earth has been recycled back in to the mantle." ❖

DEPARTMENT NOTES

Professor and Department Head **Paul Heller** was amongst several other UW faculty to receive the 2015 UW *Promoting Intellectual Engagement* (PIE) award. Recipients of the PIE Award are nominated online by sophomore students and then selected by a committee based on thoughtfulness and volume of student nominations. Student's descriptions of nominees reveal the heart of excellence in lower-division instruction courses that comprise the foundation of students' college experience and the crucial seed of intellectual self-awareness.

The PIE Award is co-sponsored by LeaRN, Ellbogen CTL, Residence Life & Dining Services, and Center for Advising and Career Services.

Professor **Kenneth Sims** recently received a National Science Foundation (NSF) grant in the amount of $267,619 to help fund his research project titled, "Toward a Better Understanding of Magmatic Processes and Volcanic Hazards at Nyiragongo Volcano, DR Congo."

Nyiragongo is a spectacular, active stratovolcano in the Virunga Volcanic Province that towers over the city of Goma in the Democratic Republic of the Congo (DR Congo), and hosts the world's largest lava lake in its summit crater. Its unusual lavas are some of the least viscous on the planet and are capable of moving at velocities of up to tens of kilometers per hour. Nyiragongo is also a dangerous volcano. It looms within 20 km of the major population centers of Goma and neighboring Gisenyi Rwanda, with a combined population of at least 1 million. Destructive eruptions in 1977 and 2002 claimed many lives and devastated infrastructure in this war torn region. The next eruption could prove disastrous in this politically volatile and economically challenged area and there is consequently an urgent need to provide a concrete scientific framework for hazard assessment and risk mitigation at Nyiragongo.

There is a dearth of scientific contributions that address magmatic cyclicity at this volcano and thus the primary goal of this research is to provide a temporal structure of past eruptions by age dating lava samples from Nyiragongo's main cone and from peripheral volcanic cones, which are especially dangerous because of their proximity to the population of Goma, with many cones residing within the city limits.

The NSF grant will run from June 1, 2015 to May 31, 2017.

Sims also recently received a 2015 UW College of Arts and Sciences (A&S) *Extraordinary Merit in Research award* and was also voted as a 2014–15 UW A&S Top 10 Teacher.

Graduate student **Jason Alexander** recently received a National Center for Airborne Laser Mapping (NCALM) award for his research project titled, "Quantifying the relationship between channel morphology and the topography of large emergent sandbars."

The award will help to have LiDAR (Light Detection and Ranging) flown in Jason's field study area on the Niobrara River in Northern Nebraska.

Jason is advised by Assistant Professor **Brandon McElroy**.

Graduate student Tyler Brown (Ph.D.) recently received an *Outstanding Student Paper Award* for a paper that he presented at the annual Fall American Geophysical Union (AGU) meeting in San Francisco, titled, "Towards solving the conundrum of fast-spread ocean crust formation: insights from textural analysis of gabbroic rocks from Pito Deep and Hess Deep, East Pacific Rise."

Only 3–5 percent of student presenters are given an award at what is the largest Earth Sciences meeting in the world with approximately 25,000 attendees. Tyler was one of nine students who received the award in the Volcanology, Geochemistry and Petrology section. This is the second time Tyler has won the award, having also won the award at the 2012 Fall AGU meeting.

Tyler is advised by Associate Professor **Michael Cheadle** and **Barbara John**.

Undergraduate seniors **Leslie Logan** and **Evan Martin** each recently received positions in the National Associate of Geoscience Teachers (NAGT)/U.S. Geological Survey (USGS) Cooperative Summer Field Training Program. Leslie and Evan were nominated by Senior Lecturer and UW Field Camp Director, **Erin Campbell-Stone**, who nominated them based on their strong performance in the summer field course for 2014.

The NAGT/USGS Training Program is the longest continuously running internship program in the earth sciences. Over the past fifty years, over 2,300 students have participated in this program, with many participants proceeding on to distinguished careers with the USGS, academia, or industry.

The program year begins in September with the field camp directors (now numbering over 120 nationally) being provided information about the program. Each director has the opportunity to nominate up to three students, based on their camp enrollment. Notated students apply by sending a resumé, letter of interest, and transcripts to the USGS. At the same time, USGS scientists interested in working with an intern submit a proposal about their field and laboratory projects. A science review and placement panel then matches candidates by their course work, skills and interests with up to five projects. The listing of candidates and accompanying academic information are sent to USGS scientists for their review. This is followed by candidate interviews and ranking for preferred selection. While the interviews provide useful opportunities for candidates and scientists for determining goodness of fit, the USGS scientist makes the final intern selection.

Leslie was also selected as a 2015 UW College of Arts and Sciences outstanding graduate.

Graduate student **Quin Miller** (Ph.D.) recently received two fellowships that will support his research project titled, "Pore network evolution in unconventional reservoirs: Experimental study of fluid-rock interactions." The research will be conducted at the University of Wyoming and three U.S. Department of Energy (DOE) national labs.

Quin, who is advised by Associate Professor **John Kaszuba**, is seeking to determine how unique geochemical reactions in confined environments, such as those occurring in pores, pore throats, and fractures, change the overall pore network of the rock. Miller recently received a graduate assistantship from the Center for Advanced Energy Studies (CAES) to support his research project. CAES is a research and education consortium among Boise State University, Idaho National Laboratory, Idaho State University, University of Idaho, and University of Wyoming. As part of his award, Miller will work in the CAES Microscopy and Characterization Suite with Professor Darryl Butt. Professor Butt is Boise State University's Chair of Materials Science and Engineering and a CAES Associate Director.

Quin has also recently been selected by the DOE to receive an Office of Science Graduate Student Research

(SCGSR) award. The award enables Miller to conduct neutron scattering experiments with Dr. Gernot Rother at Oak Ridge National Laboratory (ORNL). Additionally, Miller will continue his collaboration with Pacific Northwest National Laboratory (PNNL) Geochemist Todd Schaef, and supplement his CAES and ORNL activities with advanced spectroscopic measurements at PNNL.

Graduate students **Ryan Herz-Thyhsen** (Ph.D.), **Quin Miller** (Ph.D.), and **Alexa Socianu** (M.S.) all gave invited talks during the 2014–2015 academic year.

Ryan presented an invited talk at the American Association of Petroleum Geologists's (AAPG) Workshop, "The Bakken/Three Forks and Emerging Plays," held in Golden, Colo. titled, "Fluid-rock interactions in the Powder River Basin, Wyoming: an investigation of reactions between hydraulic fracturing fluid and unconventional reservoirs."

Quin presented a talk at the American Chemical Society (ACS) titled, "In-situ X-ray diffraction and infrared spectroscopic investigation of magnesite precipitation in interfacial water films." Quin received the *ACS Geochemistry Division Graduate Student Award*, which funded his travel and allowed him to give an extended oral presentation at the meeting.

Alexa presented an invited talk at the Houston Geological Society's annual Applied Geoscience Mudrocks Conference titled, "Importance of core and outcrop investigations for evaluating TOC distribution in unconventional systems: an example from the Mowry Shale."

All three students are advised by Associate Professor **John Kaszuba**.

Graduate student **Robert Mahon** (Ph.D.) was recently awarded a Consortium of Universities for the Advancement of Hydrologic Sciences, Inc. (CUAHSI) Pathfinder Fellowship for his proposal, titled, "Reconstructing fluvial flow and sediment transport conditions from the 3-D kinematics of bed form evolution and their stratigraphic deposits."

The $5,000 travel fellowship offers graduate students the opportunity to move beyond "one site, one view" and include a second study site into their thesis research, collaborate with a research group, and add an inter-disciplinary dimension to their research. The fellowship will fund seven weeks of collaborative laboratory flume research at the Hydraulics Laboratory at Imperial College, London with Dr. Vamsi Ganti this summer.

Robert is advised by Assistant Professor **Brandon McElroy.**

Graduate student **Erin Phillips** (Ph.D.) recently received a Goldschmidt student travel grant provided by the Geochemical Society to help fund her travel to the annual Goldschmidt 2015 meeting in Prague, Czech Republic. This annual conference is the preeminent gathering for geochemists from around the world. Erin will present a talk on her research titled, "Sr-Nd-Pb-Hf isotopes reveal the nature and evolution of mantle upwelling at Ross Island, Antarctica." Additional funding came from the University of Wyoming Department of Geology and Geophysics, a Paul Stock Foundation scholarship, and NSF grant funding to Erin's advisor, Professor **Kenneth Sims**.

Graduate student **Abraham Role** (Ph.D.) was recently awarded one of two 2015 *Dr. J. David Love Field Geology Fellowships* from the Wyoming Geological Association. The $1,000 award will be used to help costs of Abraham's research project titled "Investigating the timescales of hydrothermal fluid origins and dynamics, Yellowstone National Park, Wyoming, USA."

Abraham is also advised by Professor **Kenneth Sims**. ❖

ALUMNI NEWS

Alumnus **John Bradford Branney** (B.S. 1977) has just published his fifth book, a historical fiction novel called *Winds of Eden*, which takes place on the high plains and mountains of the Rocky Mountains, 10,700 years ago. *Winds of Eden* is the third book of the critically acclaimed *Shadows on the Trail Trilogy*, a prehistoric adventure series about the Folsom People, real-life people who inhabited North America in the late Pleistocene.

Branney retired from the oil and gas industry in 2011 and began his career as an author soon after. Other books by Branney include Shadows on the Trail, Saving Miguel, Ghosts of the Heart, and Light Hidden by Darkness. He is working on his sixth book which will be about the introduction of the horse to the Shoshone Indians in the 1600s. This still unnamed book will be published in Q2–'15.

Alumnus Jason Brown (B.S. 2004) recently started an Engineering and Geology firm in Rock Springs, Wyo. called Western Engineering and Geologists.

Alumnus **Jeff Bryden** (B.S. 1996, M.S. 1999) recently received a 2015 *Best Geoscientist award* from the Texas Independent Producers and Royalty Owners Association (TIPRO) at the fourth annual Texas Top Producers banquet, held on October 27 at the Petroleum Club of Houston. Five top winners were acknowledged across the four disciplines of Best CEOs, Best Landmen, Best Geoscientists, and Best Engineers.

The 2015 Texas Top Producer award finalists, and ultimately the top winners, were selected by a committee comprised of past honorees, in addition to industry and association executives, following an extensive open nominations process.

Bryden was also recently elected President of the West Texas Geological Society.

Alumnus **Don Cardinal** (B.S. 1958, M.S. 1959) recently won the *Robert J. Weimer Lifetime Contributions Award* from the AAPG Rocky Mountain section. This award recognizes "contributions to the practice of the geosciences and/or petroleum geology in the region of the Rocky Mountains," according to AAPG's website.

Alumnus Jeff Bryden (L) receives a Best Geoscientist award from TIPRO President Ed Longanecker (R) at the 2015 annual Texas Top Producer banquet in Houston, Texas.

The nomination from the WGA board described Don's work in petroleum geology fundamentals and exploration.

His 1984 catalog of water resistivities in Wyoming and part of South Dakota is still in use today. He took the lead in developing a stratigraphic model for the important Minnelusa and Leo formations, which was published in the WGA Guidebook and the AAPG Bulletin.

Don's prospect origination has resulted in discovery or participation in more than a dozen oil fields in Wyoming, South Dakota, Colorado and Montana. He was one of the lead geologists in the latest revision of the Wyoming stratigraphic chart, a 14-year project including a 1,300 page data set on Wyoming formations.

Congratulations to Don for the well-deserved recognition!

Alumnus **Michael McClure** (B.S. 2015) is currently working as a geologist and geotech for Inberg-Miller Engineers. He continues to utilize geophysics for the collection of geotechnical information. McClure interned with the company during the summer of 2014. During that time, he was able to use various geophysical methods to produce data that was beneficial to his clients. He is now a full time employee and the company is on board to propose the use of geophysics to our clients during various projects.

Alumnus **Selmer Pederson** (B.S. 1952, M.A. 1953) was recently inducted into the University of Wyoming Football Hall of Fame. Pederson is now retired from his position as President of Worldwide Exploration Consultants. Inc.

After receiving his Ph.D. in Geosciences at the University of Arizona in the summer of 2014, alumnus **Joshua Spinler** (B.S. 2006) worked for a year as a post-doctoral researcher in the Tectonic Geodesy Laboratory at the University of Arizona, studying the crustal deformation associated with the Pacific-North America plate boundary in southern California through the modeling of geodetic data. Additionally, he was hired as an adjunct lecturer for the spring 2015 semester to teach physical geology at the University of Arizona. Following those appointments, he was hired as a geology instructor within the Department of Earth Sciences at the University of Arkansas at Little Rock to begin the fall 2015 semester. ❖

OBITUARIES

Alumnus **Xun-Hong Chen** (Ph.D. 1994) passed away on October 22 in Lincoln, Nebraska. Dr. Chen was Professor of Geohydrology in the School of Natural Resources, University of Nebraska (Lincoln, UNL). He began his careers as a consulting hydrogeologist at TriHydro Corporation in Laramie, Wyoming. In 1994, he moved from Wyoming to Nebraska to accept a position as an assistant professor with the Conservation and Survey Division at UNL. He became a full professor with the School of Natural Resources in 2005.

Chen's work involved the analysis of groundwater systems and their interactions with streams. His research used computer models to better understand how water flows, some of which explored how groundwater irrigation affects groundwater storage and stream depletion.

UNL colleague Ron Yoder, said that Chen's groundwater research and modeling contributed significantly to the nationally and internally recognized water resources management in Nebraska.

"His extensive knowledge was valued by the water resources agencies in Nebraska, and he was respected by his students, who received a sound education in groundwater science," Yoder said. "He was a great colleague, and his many friends in the water management community will miss working with him."

"Dr. Chen was a meticulous and dedicated scientist and educator," said Gengxin Ou, a former student who is now a hydrologist at the Nebraska Department of Natural Resources. "He Cared for his students like family members. I never felt alone even though I was far away from home. He will never be forgotten."

Born Aug. 20, 1958, to Zhangcheng and Meimei Chen in Yiwu, Zhejian province, China, he earned an undergraduate degree from Zhejiang Unviersity. He was awarded a master's degree from California State University, Northridge and a doctorate from the University of Wyoming.

Alumna **Martha Ernest Monsson** (B.S. 1978) passed away on February 20, 2014 after a glen six-year struggle with multiple myeloma cancer. She was doing research up until the day before she passed away. ❖

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Photo from the 2015 annual Rocky Mountain Field Trip for new graduate students. Experts from the industry, guests and friends routinely contribute to science discussed on the trip. Here, new graduate students listen in at a stop led by Peter Hennings, formerly of ConocoPhillips, who is also Adjunct Professor in the Department.