geophysics

Colorado School of Mines

Summer 2013

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From the Department Head

Warm greetings from the Department of Geophysics. We are pleased to offer this publication as a means for you to become better acquainted with the life and spirit of our department, its people, and its programs.

We have welcomed two new faculty members in the past year – Ed Nissen and Andrei Swidinsky. Ed is using LIDAR mounted on UAV's to measure deformation in tectonically active regions. Andrei is using electromagnetics, primarily in the marine environment, to pursue various exploration objectives including characterization of hydrates. It's great to have both of them on the faculty. We also welcomed Jyoti Behura and Marios Karaoulis to our research faculty. Jyoti works with CWP faculty and students, as well as our rock physics group. Marios partners with Andre' Revil in our hydrogeophysics activities.

We are thriving with an undergraduate enrollment about 110 and grad-student enrollment just over 100. That compares with about 50 undergrads and 50 grad students when I became department head in 2000. And our graduates are in hot demand, whether they choose to take up employment or pursue further studies at the graduate level. Speaking of graduates, our Office Manager, Michelle Szobody, graduated with her BS in Mechanical Engineering this past May. What an accomplishment! We were welcomed back to Pagosa Springs this summer for a second field camp aimed at helping characterize the geothermal resource that serves that community both for heating and for tourism.

Everywhere I went when serving as President

On the cover:

Detchai "Pock" Ittharat carries seismic cables at the 2012 Geophysics field camp.

of the Society of Exploration Geophysicists, Mines alumni asked me, "Is Tom Davis still at Mines?" Approaching 40 years of service at CSM, Tom has announced he will retire in summer 2015. So "the times, they are a changin'." Pass it along – we would love to find just the right person to lead RCP for at least 30 more years!

Enjoy reading more of our news inside!

CWP Alumni Receive 2012 SEG Clarence J. Karcher Awards

The Society of Exploration Geophysicists (SEG) presented the prestigious J. Clarence Karcher Award to Center for Wave Phenomena alumni: ***Jyoti Behura*** (top, left), ***Pawan Dewangan*** (bottom, left) and ***Alison Malcolm*****.** Drs. Behura (2009), Dewangan (2004) and Malcolm (2005) were presented with their awards during the 2012 SEG Annual Meeting in Las Vegas, Nevada, The Karcher Award - given only by unanimous decision of the SEG Honors and Awards Committee as well as the SEG Executive Committee - recognizes significant contributions to the science and technology of exploration geophysics by a young scientist of outstanding abilities.

(Alison Malcolm's photo courtesy of Helen Hill)

Look for Us at SEG!

As of this printing, we are still finalizing the details of the annual department alumni event at SEG Houston. Please see Michelle Szobody at the CSM booth, #701, in the exhibit hall, or contact her at mszobody@mines.edu.

Thank you to Conoco Phillips and Marathon for providing funding for the 2013 Geophysics magazine and to all of our sponsors for their continued support of the department!

(http://geophysics.mines.edu/ GEO-Department-Support)

Producing Engineers: A Grand Challenge in Itself

Georgianna Zelenak, Class of 2013

Our society faces many grand challenges ranging from producing enough fresh water for a growing population to exploring other planets. Engineers will be key to taking on these challenges, and yet an alarming number of students drop out of engineering programs at universities around the country. The attrition rate is therefore a grand challenge in itself. At the Colorado School of Mines the graduation rate is exceptionally high within the geophysics department. It is impossible to precisely pinpoint what produces this high rate of success, but the small department size, involvement of faculty, and emphasis on hands-on learning doubtlessly play a roll. As global population grows and grand challenges must be faced other engineering departments around the country must adopt practices followed by the geophysics department in order to produce enough engineers to take on all of the grand challenges we face.

Our planet will face numerous grand challenges in the coming years. ***As the population grows and people attempt to increase their standard of living items such as food, fresh water, oil, and minerals will be in even higher demand than they are today. Engineers will have to find ways to meet this demand in a world with limited resources.*** The annual graduation rate within engineering decreased by 20% between 1990 and 2000 (Felder, 1998) and the number of engineering jobs continues to increase. Without sufficient engineers and scientists it is unlikely that society will be able to meet these grand challenges. It is therefore alarming to note that many bright students fail to graduate from engineering programs in which they were initially enrolled. One study examined 25,000 students from over 300 universities in the United States. It was found that only 43% of first-year students enrolled in engineering graduated with a degree in engineering (Felder, et al., 1998). A study specific to Iowa State University found that only 32% of engineering students graduated with an engineering degree within five years (Felder, et al., 1998). Mines faces a similar challenge. Yet, based on analysis of four successive recent classes, the geophysics department at Colorado School of Mines stands out from the rest of the school in that 91% of students registered in geophysics during their sophomore year will eventually graduate from Mines. An incredible 82% of these students will graduate with a degree in geophysics, and 77% of these students will graduate in four years or less. This success rate is due to a number of factors, including the smaller class sizes and the increased emphasis on hands-on learning with problems that are applicable to the real world.

Although specific geophysical methods cannot necessarily increase the number of engineers in society the teaching methods used by department faculty can inspire excitement for science and engineering. This excitement can motivate students to stay with an engineering degree despite difficult courses. ***The broad range of career paths***

within geophysics can also reassure students that they will not be pigeon-holed into one task for the rest of their lives. These two factors together, if applied to other branches of engineering, could help face the grand challenge of producing enough scientists and engineers for other global issues.

A prominent study in engineering education found that engineering students are more dissatisfied with the quality of their college education than majors in other fields (Felder, et al., 1998). The author of the study suggests that this could be due to the focus on lecturing and individual work. He suggests that switching to a model emphasizing active and cooperative learning could increase the satisfaction of engineering students, which could in turn help decrease the attrition rate. The geophysics program at the Colorado School of Mines is exceptional in that it already follows this new model. The majority of the major-specific classes include significant amounts of team projects and labs that require students to actively participate in order to solve real-world problems. The field session component of the degree is an excellent example of this. This past year students traveled to Pagosa Springs, Colorado in order to help a community better understand the area's geothermal resources. While some majors at the school have students sit in labs all day working on problems that have no real-world importance the geophysics students got to apply their skills to help people facing a challenge. This added an element of excitement and passion for the work that is absent in many other engineering programs.

Geophysics is also an exciting field in that it encompasses numerous branches of science and engineering and can be applied to a wide range of issues. A geophysicist has to be proficient in fields such as geology, chemistry, physics, computer science, math, and even electrical engineering. There are therefore parts of geophysics that will be interesting to most people. Once a person has a degree in geophysics they can go any number of places to tackle a wide range of problems. Some Mines graduates go on to work in exploration in the oil and gas industries while others go on to become atmospheric scientists or volcanologists. Some young students are concerned that they will be stuck at a desk doing one task for the rest of their lives. This is simply not the case within geophysics. There are opportunities for field work and office work. The number of projects to which geophysics can be applied also ensures that a person will not be stuck on one particular task unless that truly is their passion. This is undoubtedly the case with other branches of engineering as well, and yet I doubt that that fact is as clear to students. Schools should therefore take after the Mines geophysics department and broadcast to students the wide range of real-world issues for which a particular engineering degree can prepare students.

Our world faces many grand challenges today and as global population grows these issues will become even more apparent. ***In order to take on the challenges there must be a ready supply of knowledgeable, creative, enthusiastic scientists and engineers.*** Currently many engineering universities struggle with high attrition rates. This is likely due to a wide range of factors, not all of which have been clearly evaluated. However, increasing the amount of active learning and team projects as the CSM geophysics program has done could help keep interested students within engineering programs. It could also help to emphasize to students that their degrees can *continued on page* 7

Geoscientists Without Borders

Professor Roel Snieder,
W.M. Keck Foundation Distinguished Chair in Exploration Science

Geoscientists Without Borders (GWB) is a program of the Society for Exploration Geophysicists (SEG) that aims to support humanitarian applications of geoscience around the world. Following the 2004 Sumatra earthquake, Craig Beasley, from Schlumberger, kick-started the program through a 5-year, $1 million grant from his employer. Last year, Schlumberger reinforced its commitment to the program with another donation of $1 million.

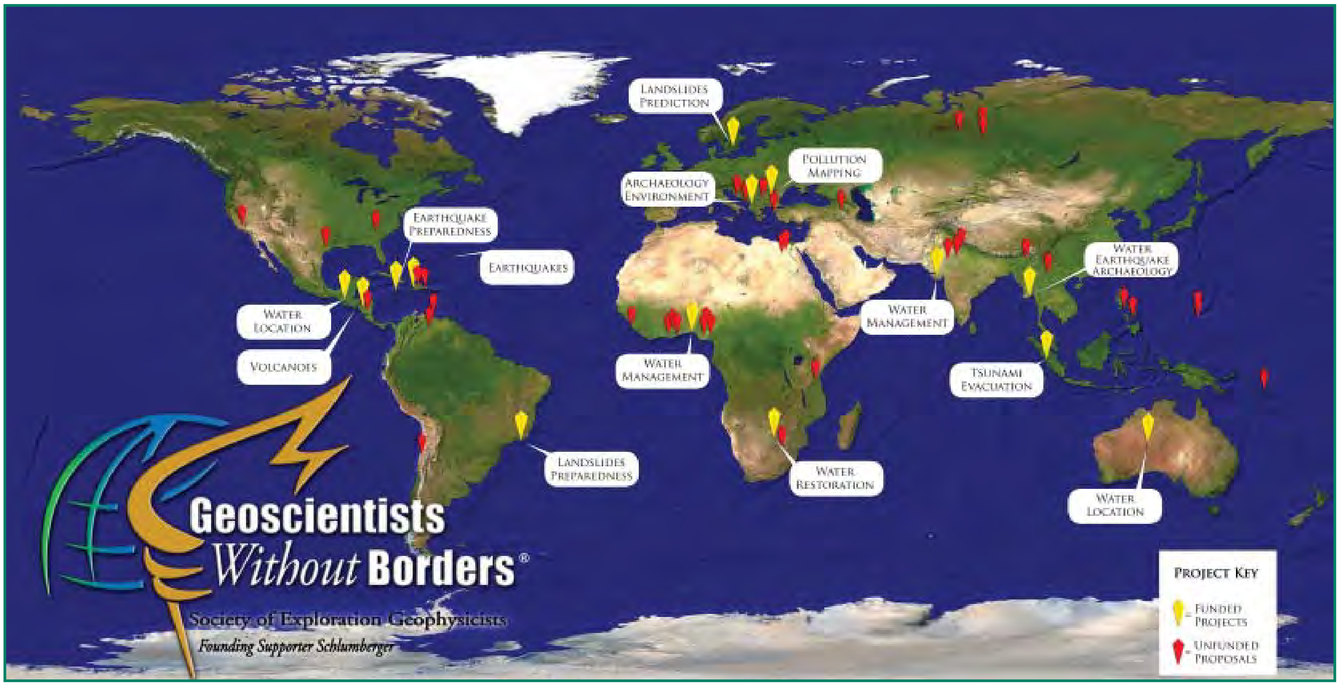
GWB funds diverse projects all over the world, covering topics such as: water management in arid areas, detecting environmental hazards, designing tsunami shelters for Sumatra and archeological surveys. Currently, all projects must use geophysical methods, involve students and transfer technology or expertise. A conversation is being held with other professional geosciences organizations such as the AAPG, AGU and GSA to broaden the scope of the program.

An example of a successful program is the water management initiative that Stephen Moysey of Clemson University carried out in India. As a result of improved understanding of the availability of water, this valuable resource could be managed more efficiently and farmers can grow three crops of rice per year instead of two. This gives immediate relief to their economic situation and it has a long-term benefit because this allows their children to attend school. CWP alumnus Kasper van Wijk carried out a project in Thailand with Lee Liberty, his colleague at Boise State University, that had the dual goal of finding archeological treasures and training the local university in using geophysical field methods.

GWB projects help solve humanitarian problems, the primary motive for implementing these projects. In addition, GWB helps to create awareness within the geophysical community of a social responsibility that goes beyond securing reliable and affordable access to resources. This sense of responsibility is further evidenced by a forum at the 2012 SEG annual meeting titled, “Corporate and Academic Social Responsibility: Engagement or Estrangement?” GWB projects allow faculty and students to work abroad, often in developing countries. This is frequently a career-defining event in the professional life of young people.

I am one of the founding members of GWB, having worked closely with Craig Beasley when the original ideas for GWB were being formed. I also served on the GWB committee since its inception, and now I am the Committee Chair. More information about GWB can be found at: http://www.seg.org/web/foundation/programs/geoscientists-without-borders.

Ongoing efforts aim to raise financial support for GWB. Currently, the program benefits from the following corporate sponsors: Schlumberger, KiWiEnergy, Santos, CGG and Global Geophysical Services; with the exception of Santos, the corporate donors are all contractors. The GWB appreciates any help to attract new corporate donors. Please contract Roel Snieder (rsnieder@mines.edu) for any ideas, suggestions, or assistance for GWB.



Current GWB projects around the world. *Image courtesy of the SEG Foundation.*

"Geoscientists Without Borders" logo courtesy of the SEG Foundation.

Producing Engineers: A Grand Challenge in Itself (*cont'd from page 5*)

lead them to a wide variety of interesting projects that could have real impact for real people. Programs such as the geophysics field camp could not be easily applied to all engineering majors, and yet taking the strong points of our program and applying them to other fields could help with the grand challenge of producing enough engineers to take on other issues facing the world.

References:

Characteristics of Recent Science and Engineering Graduates: 2008, http://www.nsf.gov/statistics/nsf12328/content.cfm?pub_id=4169&id=2, accessed 7 September 2012.

Felder, R. M., G. Felder, and E.J. Dietz, 1998, A longitudinal study of engineering student performance and retention. V. comparisons with traditionally-taught students: Journal of Engineering Education, 87, 469-480.

Welcome Andrei Swidinsky!

Andrei Swdinsky joined the Geophysics department this past April as Assistant Professor, specializing in electromagnetics. Andrei earned his bachelor's degree in Theoretical Physics from the University of Guelph (Canada) in 2005. In 2006 he completed his master's degree in Geophysics at the University of Toronto; his master's thesis involved the integration of marine electromagnetic and heat flow measurements for gas hydrate exploration. He received his Ph.D. from the University of Toronto in January 2011. His Ph.D. thesis, supervised by Professor Nigel Edwards, focused on several electromagnetic theory problems, including 3D forward modelling, imaging and inversion. Andrei was a postdoctoral fellow in the electromagnetics group at the Helmholtz-Zentrum für Ozeanforschung (GEOMAR) in Kiel, Germany from February 2011 and has been a research associate at the University of Toronto since July 2012. His current research interests include data integration of electromagnetic and reflection seismic methods for oil, gas and gas hydrate exploration, as well as geophysical methods for seafloor mineral exploration. He is married to Vika Pavelko, a graduate in commerce from the University of Guelph. Andrei loves to travel and is an avid classical pianist who enjoys performing chamber music.

Professors Ilya Tsvankin (left) and Misac Nabighian (center) autograph their books at 2012 SEG Las Vegas, joined by CSM Distinguished Scientist, Tom LaFehr (right). Rear: SEG publications manager, Ted Bakamjian, and Jennifer Cobb
Photo courtesy of SEG and Barchfeld Photography.

Paul Sava Elected to EAGE Board

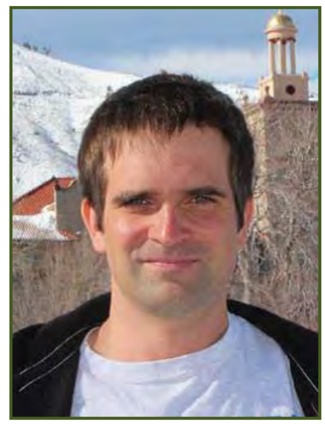
Paul Sava was elected to serve on the European Association of Geoscientists and Engineers (EAGE) Board. Paul's responsibilities as the EAGE Education Officer will focus on directing and shaping EAGE's educational activities, including but not limited to courses, lectures and student programs. EAGE, founded in 1951, is a professional association of geoscientists and engineers with a worldwide membership of commercial and academic professionals. The multidisciplinary and international association consists of members who are professionals in, or studying, geophysics, petroleum exploration, geology, reservoir engineering, mining, and civil engineering.

Jyoti Behura Returns to Mines

Jyoti Behura was appointed Research Assistant Professor in the Department of Geophysics in September 2012. Jyoti graduated from the Indian Institute of Technology, Kharagpur, with an Integrated Bachelor of Science and Master of Science degree in Exploration Geophysics (2003). He received his Ph.D. in geophysics from CSM in 2009 where he worked with Prof. Ilya Tsvankin and actively collaborated with Profs. Mike Batzle and Roel Snieder. After graduating from CSM, Jyoti worked as a research geophysicist at BP America Inc. in Houston, Texas. He returns to the Center for Wave Phenomena where his primary research interests are seismic anisotropy, attenuation, rock physics of unconventional hydrocarbons, seismic interferometry, imaging, and seismic processing.

How do people in Colorado get any work done?

Michael Behm, Post-doctoral Fellow



I joined CWP in August 2011 to work on a two-year project on seismic interferometry with Prof. Roel Snieder. My background is related to crustal-scale active seismics and near-surface studies with ground penetrating radar, so my project at CWP is an excellent opportunity to get introduced to a new scientific field. I was impressed right from the beginning by the broad scope of Geophysics at Colorado School of Mines, and by the large number of highly competent staff and students. ExxonMobil funds my project, so I visit Houston from time to time, which provides interesting insights into the different world of industry. My work focuses on extraction of local subsurface information from continuous seismic recordings. It is an interesting and challenging task. I was able to present my results at the 2012 CWP Project Review Meeting in Breckenridge, while a first paper was submitted to a journal. Apart from CSM, the proximity of the Rocky Mountains is a very big plus to living in Colorado. Being the geographically highest state in the United States, Colorado makes it sometimes hard to focus on work. The title of this article was an actual question from a similar-minded visitor whom I met while rock climbing. It is quite easy to find people with whom to share passions for the outdoors – climbing, biking, hiking, camping, fishing, kayaking, ski mountaineering or caving. A personal highlight for me was skiing down from Torreys Peak, one of Colorado's most beautiful "14ers". Most important, I was happy to make good acquaintances with people from outside and inside CWP. The ethnic and cultural diversity here is mind-opening in many aspects and eases social life for newcomers and veterans alike. I thank everyone at CWP for making my stay so splendid!

15th International Workshop on Seismic Anisotropy (15IWSA)

Ilya Tsvankin and Ph.D. student Bharath Shekar were among the participants of the 15th International Workshop on Seismic Anisotropy (15IWSA) held in Bahrain from April 14-19, 2012. The 15IWSA continued a long tradition of biennial gatherings of anisotropists that dates back to the early 1980s. The workshop was organized by CWP alumnus Abdulfattah Al-Dajani of Saudi Aramco and his colleagues from the Dhahran Geoscience Society. It was the first IWSA in the Middle East, and geophysicists from that region were well represented among the 75 attendees. The wide range of technical presentations reflected a rapid transition of anisotropy-based methodologies into the mainstream of seismic exploration and reservoir monitoring.

Ilya and his research group, the A(nisotropy)-Team, have actively participated in previous anisotropy workshops and played the leading role in organizing the 13IWSA in Winter Park, Colorado, in 2008. This time, Ilya was a member of the 15IWSA Technical Program Committee and gave a keynote lecture on seismic inversion for azimuthally anisotropic media. Bharath, Ilya and recent CWP graduate Mamoru Takanashi of JOGMEC in Japan presented five A-Team papers at the workshop. Bharath also had some good luck by winning a student drawing to get a free copy of a recent book on azimuthal anisotropy co-authored by Ilya and Vladimir Grechka of Marathon.

L-R: Ilya, Ivan Pšenčík, Mamoru Takanashi and Abdulfattah Al-Dajani

In addition to the busy technical program, the participants had a packed day of excursions to a mosque, ancient fortress (below, left), first oil well in the region, and even Formula One race track. The trip included a stop at the famous "tree of life" believed to be 400-year old (above, right). Amazingly, it grows in the middle of the desert on top of a 25-foot-high sandy hill and is the only major tree in the area.

More information about the workshop and the book of abstracts can be found at http://www.dgsonline.org/15iwsa.php. Many contributions to the 15IWSA will be published in a special section of Geophysics scheduled for July-August 2013. The next workshop (16IWSA) is planned for 2014 in Brazil, with the venue still being discussed. Workshop announcements will be distributed through the anisotropists' e-mail list maintained by John Stockwell at CWP.

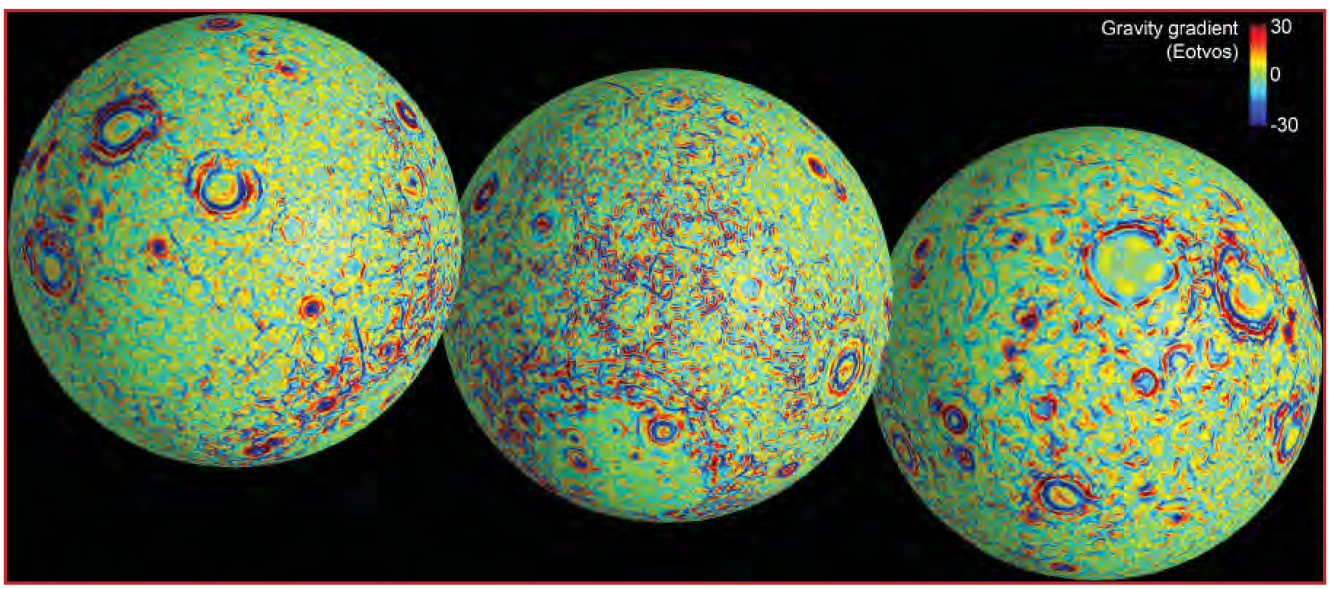
L-R: Ilya with Leon Thomsen and Andrej Bóna

GRAIL Peers Inside the Moon
Jeff Andrews-Hanna, Assistant Professor

The final picture taken by the MoonKAM camera on GRAIL – a camera that was operated by middle school students as a public outreach program. Shortly after this image was taken, GRAIL ended its mission by crashing into the Moon.

On September 10th, 2011, NASA's twin GRAIL (Gravity Recovery and Interior Laboratory) spacecraft were launched toward the Moon. The GRAIL A and B (later named Ebb and Flow) were inserted into lunar orbit on December 31st 2011 and January 1st 2012 to begin their mission. This mission was designed to generate a high-resolution gravity map of the Moon, using the same technology that the GRACE spacecraft used for the Earth. A simple measurement of the distance between the two spacecraft as they orbit the Moon is used to generate a global gravity model. While the thick atmosphere of the Earth forces satellites to orbit high above the surface, satellites around the airless Moon can orbit at very low altitude, allowing them to make higher resolution gravity measurements. The result was the highest resolution global gravity map of any planet (including the Earth). The gravity model at the end of the prime mission had an effective resolution of ~15 km.

I became involved in the GRAIL mission as a guest scientist, contributing to the analysis and interpretation of this groundbreaking dataset. Having learned a few things from my colleagues Yaoguo Li and Misac Nabighian, I found myself wondering what lunar gravity gradients would look like. In the first study of its kind,



Globes of different orientations showing the Bouguer gravity gradient data [Andrews-Hanna et al., Science, 2013].

I generated global Bouguer gravity gradient maps of the Moon in order to highlight the finer details of the gravity field. The result contained a number of surprises. Lunar impact basins are known to be surrounded by systems of tectonic rings, though these rings are often poorly expressed or incomplete at the surface. The GRAIL gravity gradients reveal these rings in exquisite detail, and are helping *continued on page 29* .

FACULTY/PLANETARY

Planetary Geophysics Lab

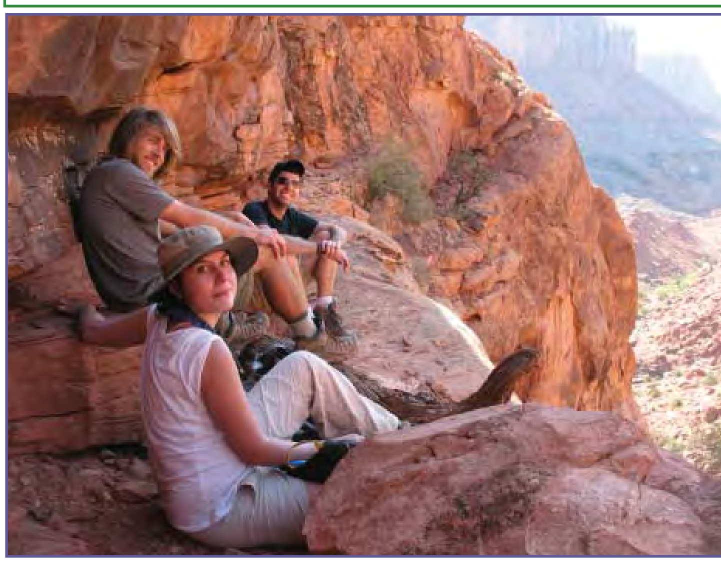
The 2012 Planetary Analogs Field Trip

Dave Horvath, PhD Student

This year, the Planetary Geophysics Lab had the exciting opportunity to participate in a student-led planetary analog field camp through eastern Utah and southern Idaho. The group, consisting of Brian Davis, David Horvath, Ezgi Karasozen, Yaser Kattoum, and advisor Jeff Andrews-Hanna, analyzed the formation mechanisms of a number of geological features ranging from volcanoes to paleolakes, and discussed how they relate to features we observe on other planets.

Our first stop was in the arid Moab desert where Yaser Kattoum led the group to Upheaval dome, a 5 km diameter depression with a central uplift, in search of evidence that this structure is in fact a preserved impact crater. The violent nature of the crater-forming process creates distinct geological features in and around the crater. Large impacts observed on other planets are characterized by an uplifted peak in the center of the crater or a ring structure inside the crater. The origin of the uplifted peak in the center of Upheaval dome has been the debated as either being of impact origin or a salt intrusion, leading to the need for further observations outside the crater rim. Using published studies of the crater as a guide, we observed extensive faulting, deformation bands, and clastic dikes on our long journey around the dome, supporting an impact origin for this structure. Although Yaser promised us a "three hour tour", the march around the dome took the entire day and the group was glad to be out of the 110°F desert by the end. While erosion erases much of the evidence for cratering on Earth, well-preserved impact craters are ubiquitous on other planets. This leg of the trip tied in nicely with Yaser's work on the much larger Orientale impact basin on the Moon.

Our next stop led us north to the Salt Lake City region, where we explored the ancient Lake Bonneville, which dried up to become the present-day Great Salt Lake and Bonneville Salt Flats. Led by Ezgi Karasozen, we were able to observe ancient shorelines of the prehistoric Lake Bonneville from Antelope Island in the Great Salt Lake. The wetter climate during the Pleistocene caused Lake Bonneville to overflow the basin, flooding the surrounding region creating large mega-ripple structures visible all the way north into Idaho. The Bonneville flood is a good analog to the outflow channel floods on Mars, and paleolake Bonneville is analogous to the many dried up martian lake beds, including Gale crater where the Mars Science Laboratory is currently roving. These regions have the greatest potential for habitability in Mars' past. The geology on the island also offered a window into the Earth's earlier climate history, including an unconformity that could be related to the transition



Ezgi, Dave, and Brian taking a break on the hike around Upheaval Dome in Canyonlands National Park.

from a “snowball” to a “hot-house” Earth. This area was also a good place to view the structures of the Basin and Range province, which may be analogous to the South Tharsis Ridge Belt on Mars that Ezgi is studying.

In search of volcanic constructs, the group made their way north to Idaho, where Brian Davis led us to Craters of the Moon National Monument and the Snake River volcanic plain. Despite its name, Craters of the Moon is actually a relatively young basaltic flow that occurred after the formation of the Snake River Plain. Melting under the Yellowstone hotspot approximately 16 Ma is thought to have caused periodic rhyolitic eruptions that form the majority of the Snake River Plain. Later volcanism (between 10,000 and 2,000 years ago) is characterized by less extensive basaltic flows, possibly caused by regional tectonics. At Craters of the Moon and other flows in the region, the group observed basaltic and rhyolitic constructs, fissures, well-preserved lava tubes, spatter cones, and cinder cones all associated with this late stage volcanism. To obtain a closer look at these features the group did a bit of spelunking through the hollowed out lava tubes and descended into the once-active volcanic fissures where the dikes feeding these features could be studied in detail. Similar dike fed fissure-style eruptions and their associated cones and flows are observed in the Tharsis province on Mars, where Brian is focusing his research. Our campground for the night was a remote spot surrounded by the lava flows.

The final leg of the tour was headed by David Horvath and found the group at Box Canyon in southern Idaho. Box Canyon is a short tributary of the Snake River, and while currently fed primarily by groundwater spring discharge, its initial formation may have been caused by an ancient catastrophic flooding event. Evidence for this is apparent leading up to and on top of the canyon where scour

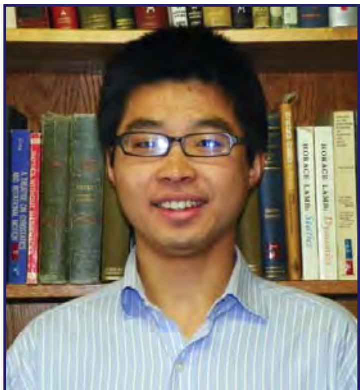
Exploring a volcanic vent at Craters of the Moon NM

marks oriented towards the canyon head are present on the bedrock, indicating a discharge large enough to entrain pebble sized sediment. The abrupt amphitheatre style headwall of the canyon and lack of fluvial activity feeding the canyon suggests that groundwater may have also played a role in the formation in this canyon, weakening the rocks that would eventually be eroded out by the ensuing flood. The sediment at the bottom of Box Canyon seemed an important indicator of the past discharge through the canyon, and the group found it necessary to take a quick swim break to study these further. After the hot desert hike to begin the trip, the cold, spring fed water was a refreshing change. This portion of the trip tied in nicely with Dave’s planetary hydrology research on Titan and Mars. Stubby, amphitheatre headed canyons are also observed feeding canyon systems on Mars where groundwater is thought to play an important role. As observed at Box Canyon, groundwater alone may not be enough to remove the necessary sediment out of these canyons, which may suggest periodic flooding events in Mars geologic history.

Finally, we turned around for the long drive back to Golden. It was a long week, but we all learned a lot about the Earth and other planets as well. Along the way, we enjoyed some of the finest camping, hiking, and scenery that the west has to offer. Although we focus most of our efforts on analyzing satellite remote sensing data and running numerical models, it’s beneficial to get out in the field to explore this planet we are living on.

Center for Gravity, Electrical and Magnetic Studies

Joint Inversion of Multiple Geophysical Data Sets



Jiajia Sun, PhD student

Geophysical inversion has proven to be an indispensable tool in quantitatively estimating the distribution of physical properties in the subsurface and delineating the location and geometry of targets in petroleum exploration. Conventional implementation of geophysical inversion has been based on one single type of geophysical measurement, such as gravity or seismic data. For exploration in complex geological settings such as sub-basalt, such an approach may sometimes fail to provide useful information about the target reservoir due to complicated wave phenomena such as seismic wave scattering, internal multiples, mode conversions and attenuation.

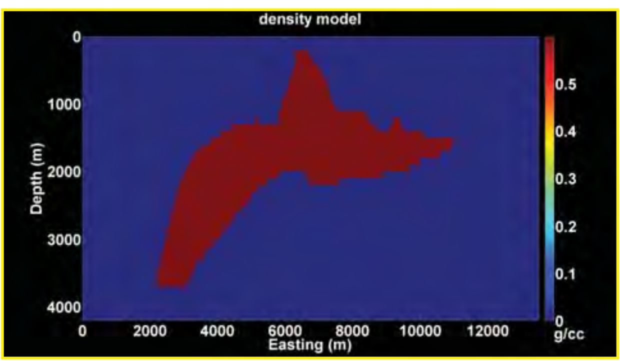


Figure 1 (left): True density model. Generated based on SEG/EAGE salt model.

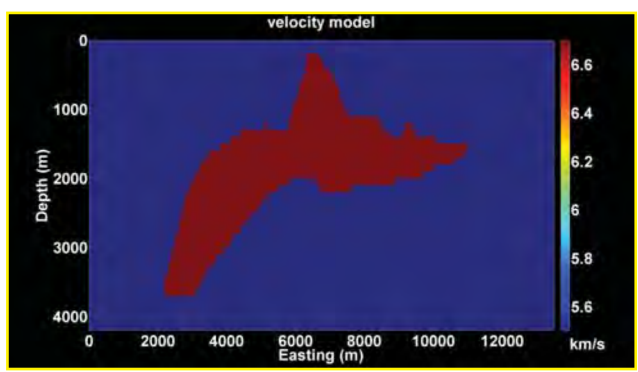


Figure 2 (right): True velocity model. Generated based on SEG/EAGE salt model.

Joint inversion, on the other hand, inverts multiple geophysical data sets within a single inversion scheme. Each geophysical data set is sensitive to a different physical property and based on fundamentally different physical laws. Therefore, joint inversion provides a means to integrate different yet complimentary information from different geophysical data, and if appropriately implemented, results in a better image of the subsurface structure.

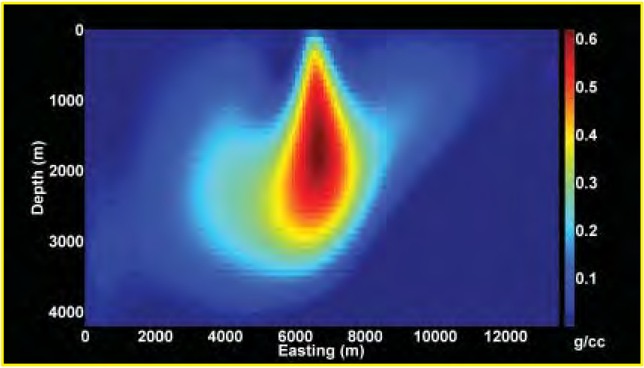


Figure 3 (left): Inverted density model using only gravity data.

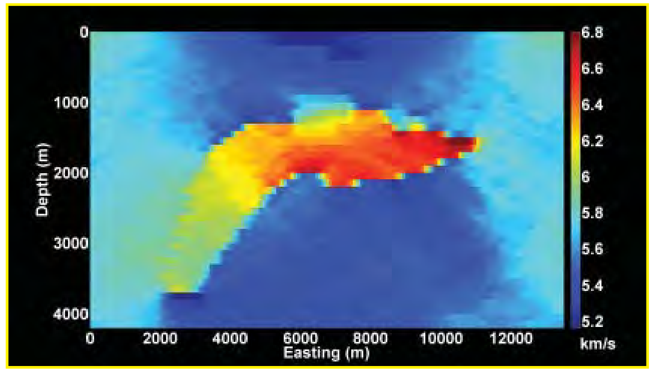


Figure 4 (right): Inverted velocity model using only seismic traveltimes.

Depending on the specific objectives of doing joint inversion, there are different approaches. One of the methods I proposed in my PhD thesis research is joint inversion using fuzzy c-means (FCM) clustering to incorporate *a priori* petrophysical information available from well logging or laboratory measurements. The resulting physical property models honor not only the observed geophysical data but also the rock physics data, and therefore, represent the subsurface better than those models inverted from one single type of geophysical data.

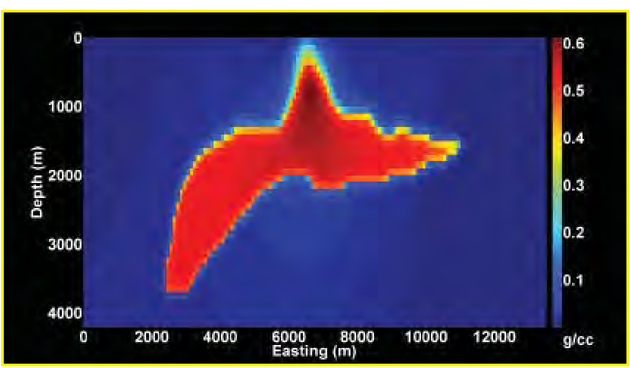


Figure 5 (left) : Inverted density model from joint inversion.

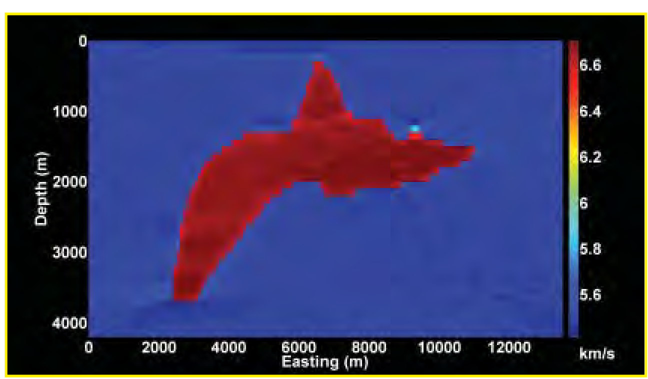


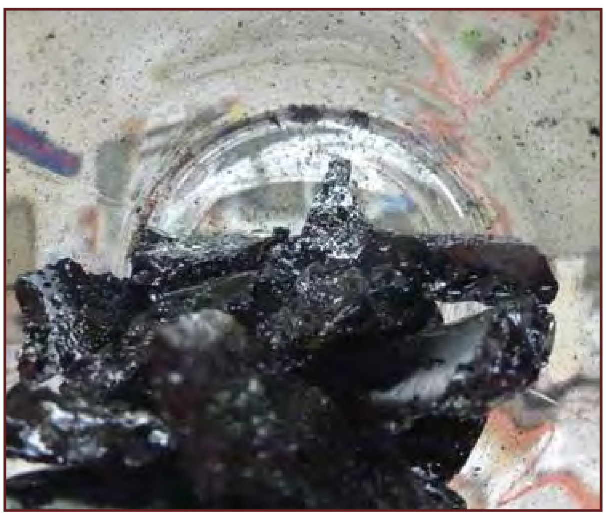
Figure 6 (right): Inverted velocity model from joint inversion.

CGEM

Center for Rock Abuse

Heavy Oil and NMR
Patricia E. Rodrigues, PhD student

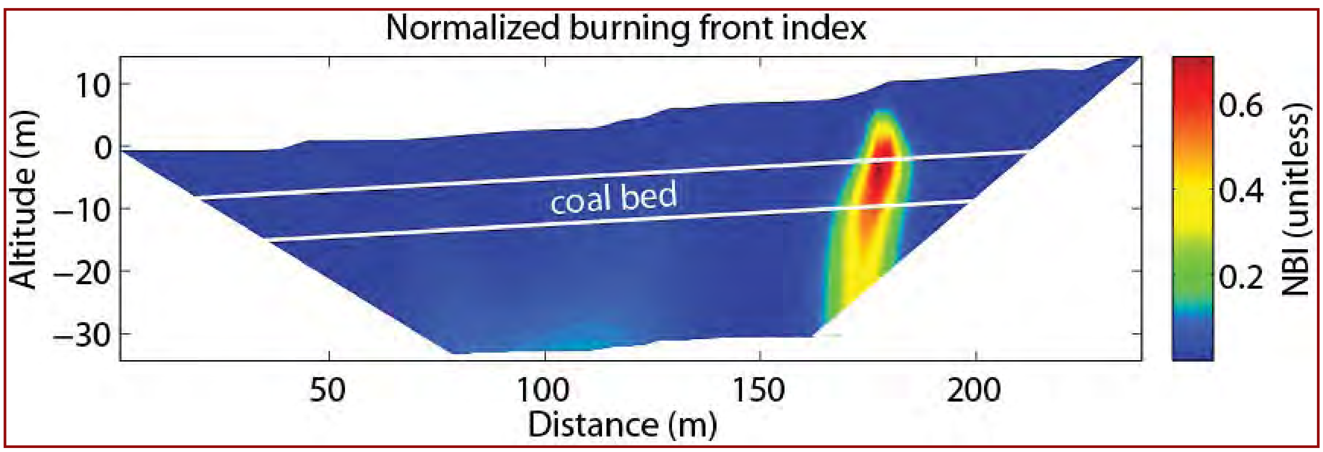
After working in petrophysics for many years, coming to Colorado School of Mines to work with Mike Batzle was not just a natural place to go, but a real privilege. I started my career in the Venezuelan national oil company (PDVSA) after graduating from Chemical Engineering at Universidad Simon Bolivar in Caracas. While working at PDVSA, I finished a one-year Reservoir Engineering Specialization and later a Masters in Chemical Engineering. During my first weeks at work, I still remember my shock when I learned that the oil was found inside a rock and not inside a big pool under the surface! I'm glad there were no witnesses but myself that could tell the story; now I can do it safely 15 years later. Interestingly, those rocks are now the center of my professional career as a petrophysicist and, the oil within those rocks, the center of my research at the Center for Rock Abuse here at CSM. My master's thesis work is predicting the viscosity of heavy oils using nuclear magnetic resonance (NMR) techniques. Heavy oil is an important energy resource, in particular in the western hemisphere. Its high viscosity is an obstacle to production and reducing it is the main objective of many Enhanced Oil Recovery (EOR) techniques. As I began working in the Center for Rock Abuse in 2010, I had in my mind I was going to work with "unconventional" rocks, of which we find plenty in the Rocky Mountain region. However, I found myself again working with shear properties of heavy oils. I first reviewed some of my previous research and found new analysis techniques to predict the viscosity of heavy oils from NMR signals. After delays aquiring NMR equipment, I began to study the shear properties of heavy oils from a different point of view: frequency dependency. I am currently studying the shear properties of heavy oils at low frequencies using rheometer data and comparing these results to higher frequency data. My research has the purpose of providing rock physicists with a way to predict the shear properties of heavy oils at the different acquisition frequencies of acoustic data we find in geophysics. The objective is to link the shear properties to the heavy oil composition and reservoir conditions.



Coal Seam Fire

André Revil, Associate Professor and
Marios Karaoulis, Research Assistant Professor

Coal seam fire is a generic name giving to in situ burning coal. The ignition of coal seam fire can being through the direct influence of oxygen through exothermic reactions, or anthropic. The fire can smoulder underground for decades and possibly hundreds of years. These fires have numerous social, economic, and ecological impacts. In 2002, an underground coal burning for nearly a century started a coal seam fire near Glenwood Springs, Colorado, and was responsible for the destruction of 29 homes and 14 outbuildings and a total of $6.4 million in insured losses. About 12,200 acres burned during this event. The detection of the burning fronts of a near-surface coal fire is of paramount importance prior to develop any strategies to extinguish them. We have been using self-potential and DC resistivity on a small coal fire near Boulder Colorado, developing a joint inversion strategy for the inversion of these data and to locate the burning front.



Determination of the Normalized Burning front Index (NBI) from the jointly inverted self-potential and DC resistivity data. High values corresponds to a high probability zone in terms of recovering the position of the burning front. Note that the depth of the maximum of the NBI coincides with the depth of the coal bed (approximately 10 m).

Reservoir Characterization Project

A Geologist's View of RCP

Heather Davey, MS Geology, 2012

As a member of the Reservoir Characterization Project (RCP), I spent the last year and a half learning and achieving more than I ever anticipated when starting my MSc in September 2011. My thesis was focused on geomechanical characterization of the Montney shale, a new RCP project initiated in April 2011. This work included stress and fracture characterization, Mohr-Coulomb failure analysis, production data, microseismic, and time-lapse seismic correlations. I received a broad knowledge base from the wide variety of classes available at CSM. Most of my professors were previously employed by industry and had a keen eye for what information is most valuable to impart to students. Aside from my thesis and course work, RCP itself was exceptional in providing real-world skills necessary to be successful in future jobs. Learning how to present well, interact professionally with colleagues, and work as part of an integrated team were the most valuable skills I gained. I don't believe I would have received all of this in other settings.

IN PURSUIT OF NEW IDEAS

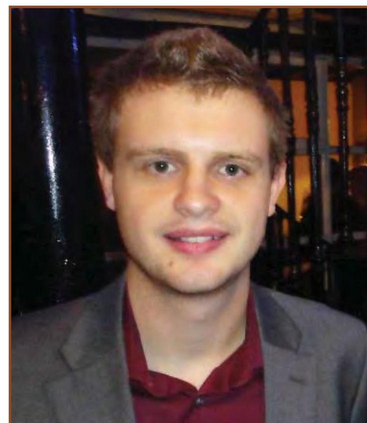
The Reservoir Characterization Project (RCP), created by Tom Davis in 1984, continues to provide a unique working environment for its members pursuing MSc and PhD Degrees. The original vision for the group was to approach projects using a collaborative and inter-disciplinary approach. This method maximizes the interaction among the disciplines of geophysics, geology, and engineering, and opens the door for discussion and rigorous review of RCP projects from a harmonized team. RCP is also host to students from a wide variety of cultures, strengthening its unique and broad vision. Past and current projects maintain a strong focus in multi-component seismic acquisition, starting with the first phase, the Silo Field (Wyoming, 1985), and continuing to the recent unconventional phases brought forward in 2011, namely the Banner project (Bakken formation, North Dakota), the Long Lake project (heavy oil, Alberta), and the Pouce Coupe project (Montney formation, Alberta). The shift in focus to

RCP fall 2012 graduates: Andrea Vega, Xinhui Min, Heather Davey, Antonio Velasquez unconventional shale and heavy oil in recent years displays RCP's ability to stay current and successful within the changing emphasis of the oil & gas industry.

Strong industry support is evident in the RCP group. Sponsors not only provide real-world projects but also provide individual mentorship to students. This is an essential factor in the success of the group. RCP students are strongly encouraged to interact with industry sponsors as well as each other. The active engagement of students with sponsors and vice-versa provides the essential teamwork skills which prove vital in future job opportunities.

The ability of RCP to prepare students for real-world employment is evident in the broad range of post-graduate opportunities which are offered. RCP graduates currently hold positions in various locations throughout North America, South America, and Europe. Employers recognize the work ethic and professionalism that characterize an RCP alumni. As a result, students are highly sought after and have the opportunity to pick the best fit for both themselves and their future employer.

RCP Student Profile: Matthew Lee, MS Student, Teesside, England



What was the focus of your undergraduate research? How did you become interested in this topic? *My undergraduate research was modelling moment tensor inversions in the presence of finite fractures. Basically testing how accurate an MTI can be in a purely homogeneous medium (no fractures and known velocity field) compared to when fractures are introduced around the source. The project was a synergy of my advisors' interests and my own; they set me off with a general idea and I molded it from there.*

Why did you choose the RCP group over other consortia and schools? *I got to know the research group and the school from my exchange year here 2 years ago and I decided to come back because of my experiences then. I chose RCP because of the work they focus on, industry connections and reputation, and knowing the leaders of RCP. They are a very friendly group and provide a hard-working atmosphere.*

What RCP project will you be working on and what are you most looking forward to in your thesis work? *Montney Shale Microseismic. Extracting multiple microseismic results and analysis, which will hopefully support the work and results that have already been determined in the study area. My work will be slightly different from what others are doing, and what is traditionally done in RCP.*

Where do you see yourself in 10 years? *Hopefully as part of a microseismic team in an oil/gas company where I will also be able to integrate my work with results from other groups to come up with accurate answers that engineers require to execute well development properly.*

What new directions do you see geophysics taking in the next few years? *With the growth of the unconventional fields in the oil industry I think the focus will be on work that can monitor and increase the effectiveness of hydrocarbon extraction in these plays, hopefully involving more microseismic! I believe this will be particularly important when considering the environmental concerns associated with these reservoirs.*

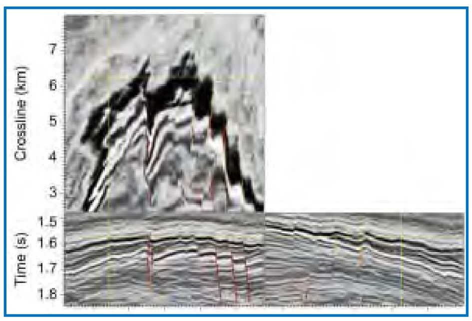
Unfaulting and Unfolding 3D Seismic Images

Simon Luo, PhD student

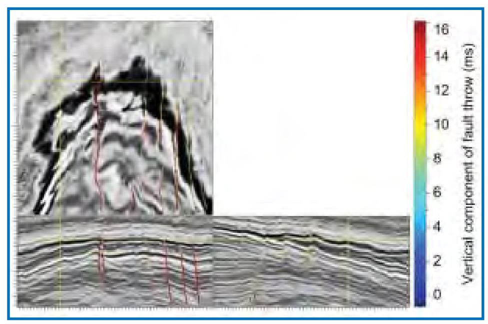
Interpreting seismic images is a common, but often times tedious, task in exploration geophysics. For example, to identify geologic horizons in the 3D seismic image shown in Figure 1a, an interpreter might manually pick points on each horizon. A better alternative, however, would be to process the seismic image so as to automatically identify and extract geologic horizons.

To automatically extract geologic horizons from the seismic image shown in Figure 1a, we first estimate fault surfaces and fault throw vectors (relative displacements along the dip direction of a fault), the vertical component of which is overlaid on the seismic images in Figures 1a and 1b.

1a)



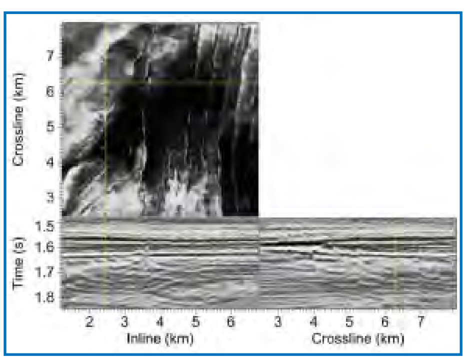
1b)



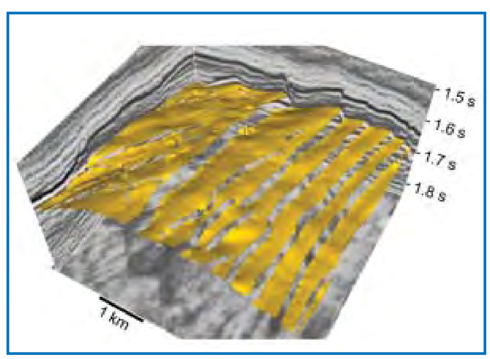
After interpolating estimated fault throw vectors at locations between faults, we unfault the seismic image shown in Figure 1a to obtain the unfaulted image shown in Figure 1b. In this unfaulted image, events are more continuous across faults, but are still deformed due to geological folding. Next, using a method for automatic seismic image flattening, we unfold the unfaulted image shown in Figure 1b to obtain the image shown in Figure 1c. In this unfolded and unfaulted image, sedimentary layers are horizontal and are also aligned across faults.

An unfolded and unfaulted image is an image of relative geologic time, in which a surface of constant time (i.e., a horizontal slice) maps to a geologic horizon. We can then easily extract geologic horizons from horizontal slices in an unfolded and unfaulted image. An example of one such horizon extracted in this way is shown in Figure 1d.

1c)



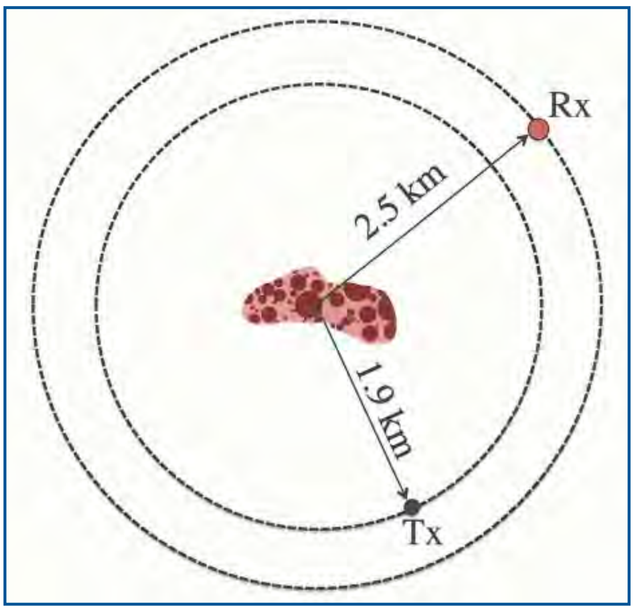
1d)



Imaging Asteroids and Comets

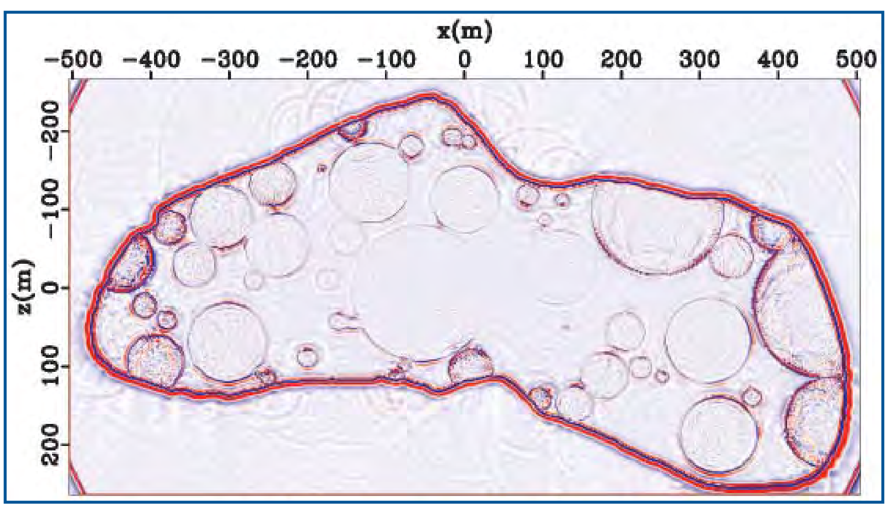
Pock Ittharat, Class of 2013

My name is Detchai Ittharat, but I go by "Pock". As an undergraduate and member of the Center for Wave Phenomena (CWP), I conducted research in the area of seismic imaging and associated computational methods. I worked specifically with Professor Paul Sava on a project entitled, "Foundations of Radar and Seismic Imaging of Asteroids and Comets", sponsored by the Southwest Research Institute in Boulder. The goal of the project is to investigate the physical properties of asteroids and comets in space using electromagnetic wave propagation coupled with seismic processing techniques. Sources and receivers for this remote sensing activity would be satellites orbiting the comet or asteroid, so one challenge is designing a data acquisition process that will succeed in providing the information required. I was really excited about getting the chance to do this research activity in addition to the interesting courses I took as an undergrad. The combination of coursework and research has helped to shape my thoughts about the future.



Left: Dual orbiters of the asteroid exploration acquisition.

Right: A migrated image of the interior of an asteroid with dual orbiter acquisition.



CWP

Earthquake Seismology in South America

Kendra Johnson, PhD student

I grew up in the small (but growing) city of Durango in the southwest corner of Colorado. The stereotypical Durango local (also called a "Durangotang") binges on outdoor adventures, is hardly phased by sporadic weather, and has quite possibly invested more in mountain or river toys than automobiles and residences; these characteristics rubbed off on me. I also grew fond of the size and atmosphere of Durango, finding comfort in a small and friendly population; this convinced me to find a similar Colorado setting in which to spend my college years. I found the cozy town of Golden, Colorado and it's college complement, the Colorado School of Mines (Mines). Conveniently, I wanted to study math and science, as these are the school's almost exclusively applied subjects, so I spent four years at Mines and earned an undergraduate degree in geophysical engineering. Near the end of my third year I started working at the U.S. Geological Survey (USGS) under David Wald on the ShakeMap Atlas 2.0. ShakeMap is a program that geospatially maps the ground motions and shaking intensities for any earthquake, and the Atlas is a compilation of these maps for several thousand significant (in terms of both human and economic losses) global earthquakes from the last few decades. In building the Atlas, I was "forced" to look at ShakeMaps for major earthquakes that demonstrate how earthquake type, geographical/geological setting, societal structure, and other factors affect the way that a seismic event impacts the public. I consider my experience at the USGS both a basic introduction to earthquake seismology, and a motivation to continue my education in the field.

I loved Mines so much that I decided to stick around the Geophysics Department for another four years or so, this time focusing on the tectonics and natural seismicity of western South America. I am currently in the initial steps toward a PhD under a joint advisory with Dr. Edwin Nissen, the newest addition to the Mines geophysics faculty and first to focus specifically on tectonics, and Dr. Gavin Hayes, a member of the USGS National Earthquake Information Center and adjunct professor to the school. My research will extend from the subduction processes west of South America where the Nazca and South American plates converge (Dr. Hayes) to the associated deformation involved in shaping the Andes Mountains (Dr. Nissen). I have just completed my first year of graduate school and am quickly becoming excited about my research. I'm also glad to have the opportunity to focus on such an intriguing science in the great town of Golden, Colorado.

Our field trip guide at a site of crustal uplift. Before the earthquake, much of this field was covered by marshlands.

My research in fall 2012 aimed to constrain strike and dip sensitivity of RMT solutions for aftershocks of the 2010 MW 8.8 Maule earthquake. Based on this, I was invited to attend a workshop focusing on the aftermath. Dozens of scientists from all over the world congregated in Concepción, Chile to share research results, assess response efforts, and plan for future events.

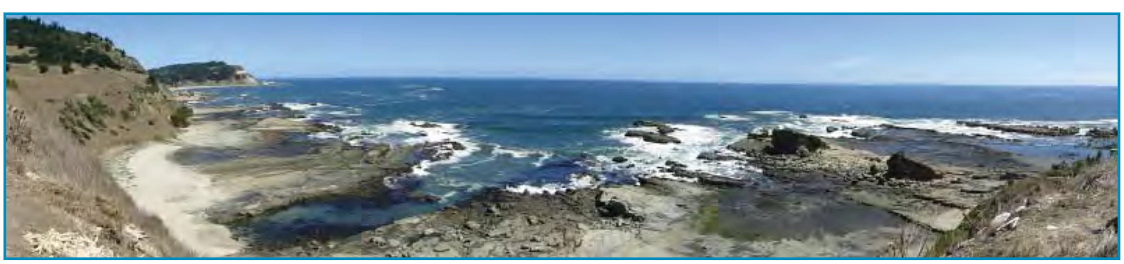
Left: Tsunami warning sign

Right: Houses built on stilts.

Within the first couple weeks of the mainshock, responders had deployed seismometers, GPS stations, and tide gauges in the mainshock region; other scientists recorded geological and tsunami observations, or evaluated satellite data. We spent the first two days of the workshop enjoying presentations, posters, and discussion on how scientists integrated different combinations of the collected data to understand the earthquake and seismogenic zone. Some scientists also incorporated paleoseismic records and historical earthquake information. I found myself very impressed with the variety of studies possible from the Maule dataset, and felt both inspired and proud of worldwide scientists' dedication to understanding the complexity of hazardous subduction zones.

We also visited coastal sites that suffered from coseismic crustal uplift and/or tsunami damage. The first field trip took us southwest of Concepción to the Arauco Peninsula, which extends westward from the coast toward the oceanic trench. While the bulk of the overriding plate subsides after a subduction earthquake, the crust close to the trench is uplifted; this was the case for much of the Arauco peninsula, which uplifted by 1-2 m. Before the earthquake, shellfish production was an important business on the peninsula. Uplift has minimized the size of marshlands, which severely hurt the shellfish economy. Our field guide estimates 2 years (from 2013, not the earthquake) before they recover. The second field trip occurred along coastal sites further north, which experienced significant tsunami damage. One location, the Dichato Bay, was almost completely destroyed by the tsunami; only the bathrooms in most buildings remained standing. Boats and debris were washed ashore and giant tsunami waves demolished buildings. Rebuilding efforts have propped buildings on stilts that may protect from future tsunamis. The Bay also constructed a tsunami retaining wall along the coast.

Before this trip, I didn't understand the detriments of crustal uplift to coastal societies. When the news publicizes huge subduction earthquakes, we first hear about damages by shaking, then tsunamis, and sometimes other secondary hazards flooding and fires. Crustal uplift is a strange consequence; the rebounding crust does not necessarily pose an immediate hazard, but reshapes the earth. By traveling to Chile, I learned things that news reporters could not teach me.



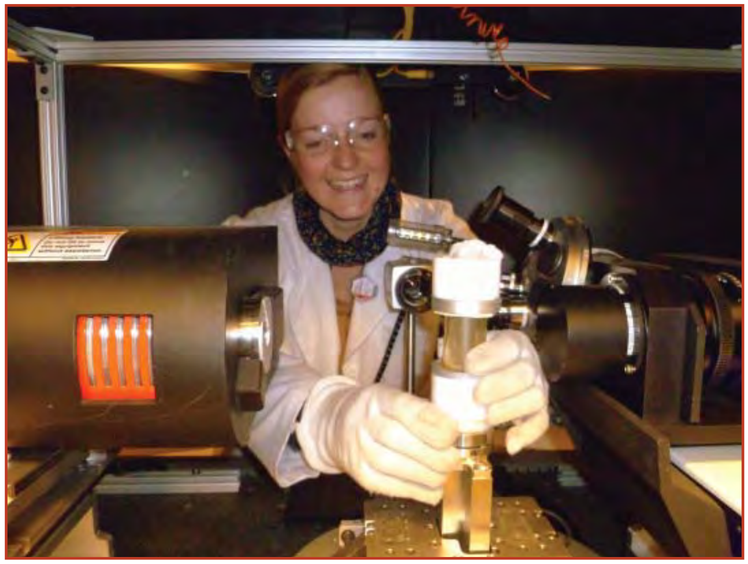
Site of crustal uplift, and beautiful ocean view

Aside from attending the workshop, I spent some time sightseeing and enjoying the Chilean culture. I visited the highest topographic point in Santiago, tasted a pisco sour – a common drink in South America, and listened to live music. I had a wonderful time, and am very grateful to the Incorporated Research Institutions for Seismology (IRIS), who funded my travel, and my project advisor Dr. Gavin Hayes for the incredible opportunity!

Rock Physics Nerd

Mandy Schindler, PhD student

Center for Rock Abuse



The first time I came to Colorado School of Mines was in 2010. I was working on my master's degree at Freiberg University of Mining and Technology in Germany and wanted to spend some time abroad. My adviser highly recommended Colorado School of Mines, so I spent one semester working as a visiting researcher at the Center for Wave Phenomena. I was working on the seismic processing of a 4C OBC (four-component ocean bottom cable) dataset. This was a great opportunity to apply what I learned during my previous studies to a topic of practical relevance. I really liked the working environment in that versatile group of students and faculty. Back then, I also made my first contact with the rock physics work group.

Since I just could not get enough of Colorado, Golden and School of Mines, I decided to visit once again and do the research for my master's thesis at the Center for Rock Abuse. Since six months is a very limited time to get enough results for a whole master's thesis, I did almost nothing else but work in the lab. Surprisingly, I still liked what I was doing. Thus, I developed the plan to do that for a slightly longer time and applied for Ph.D. at Mines. My research topic is the rock physics of gas-hydrate bearing sediments.

When I am not abusing rocks, I like to hound them and Colorado is a great place for that. Because of Colorado's mining history, there are tailings to roam everywhere. You can find a huge variety of minerals and fossils. That is something I really appreciate about this area, especially in combination with hiking and photographing the amazing Colorado landscape.

A New Challenge

Paul El Khoury, MS student

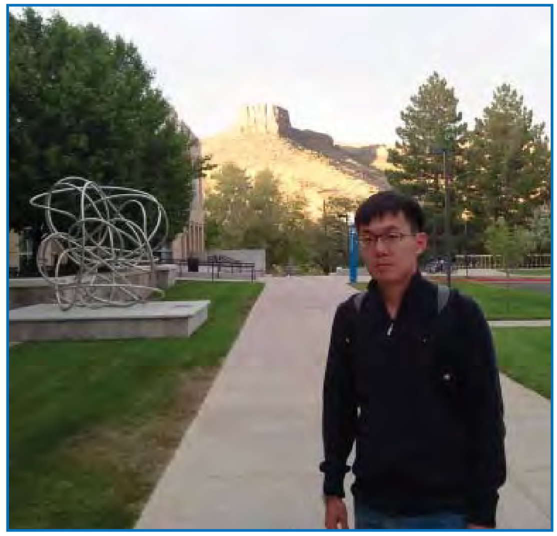
Hydrogeophysics & Porous Media

I am from Lebanon, the heart of the Middle East, the land of Phoenicians, cedars, unique culture and great food. In June 2012, I received my bachelor's degree in Mechanical Engineering from the American University of Beirut (AUB). I had never thought of pursuing graduate studies after obtaining my degree in Engineering specializing in Geophysics. However, an internship at Schlumberger, two courses in petroleum and reservoir engineering as well as receiving the ExxonMobil MENA Scholarship changed the whole story and fueled my interest in geosciences. Thus, the world renowned Geophysics Department at Colorado *(cont'd on next page)*

A Huge Stepping Stone to Advancing My Career

Vladimir Li, PhD student, Center for Wave Phenomena

I am originally from Moscow and I received my M.Sc. in Exploration Geophysics from Moscow State University in 2010. It was really a nice time in the great university and in a wonderful city. Having graduated from Moscow State University I realized that I wanted to continue my education in the area of geophysics and that the U.S., the center of world science, could be the best option.



Mathematics and physics always appealed to me, and my studies at MSU geology turned out to be quite an interesting field for application. Being an undergraduate student I realized that geophysical problems are quite complicated, and their solutions (if they exist) could be non-unique and unstable. Upon completion of my junior year I started working in the sphere of shallow exploration seismology and I was able to take a look at it from a practical perspective which gave me further evidence about the complexity of geophysical problems. I saw that near-surface media are extremely complicated, significantly heterogeneous and anisotropic. So, all of that together provided a good incentive to learn more about wave propagation in complex media. By the time I browsed and narrowed down the circle of universities doing exploration geophysics I had already known that Colorado School of Mines holds the reputation of the strongest school in the US as far as Geology and Geophysics. In particular, I realized that CWP is considered one of the leading groups in the sphere of theoretical geophysics and mathematical and computational methods. I was also excited to know that one of the best specialists in the area of seismic anisotropy Prof. Ilya Tsvankin, who had also graduated from Moscow State University, is leading an anisotropy team in CWP.

I am very glad to be here at CWP being led by high caliber specialists and I am enthusiastic about getting started with my research and taking more classes offered by the CWP professors. It seems like problems and approaches to solving them have risen to a new level, and it is pretty challenging. I think that entering CSM and particularly CWP is a golden opportunity to delve into theoretical geophysics and a huge stepping stone to advancing my career.

In addition I can say that Golden is a very nice place to spend leisure time. As far as I can see my time here is going to be replete with hard studies and it is nice that I can ease this discipline with hiking, travelling and of course skiing.

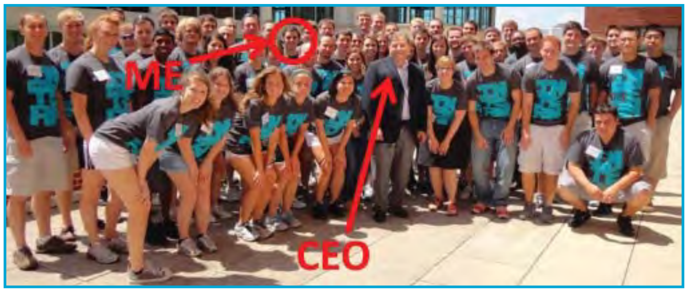
School of Mines was the best place to learn and develop my knowledge in this field of study.

The overseas journey began from Kfarchima, my home town at the outskirts of Beirut, to Golden. The past few months, I adhered to the American culture, enjoyed the great dry weather of Colorado, discovered the beautiful nature as well as examined the origin of Colorado's rocks and formations (Thanks to GEOL501). From designing machines, analyzing motion, manufacturing devices to examining, exploring and producing earth's treasure, a new challenge in my life has just begun.

Applying AVO at Newfield Exploration, Denver

Andrew Munoz, PhD student

During my summer at Newfield Exploration, I was given the task of mapping an impactful prospect in the Uinta Basin of northern Utah using a new multi-component seismic dataset Newfield acquired over their acreage.



I was the only geophysicist in the Denver office. I used AVO (amplitude variation with offset) inversion as a tool to detect and quantify an important resource never previously mapped, while learning how to do advanced seismic processing of the newly acquired seismic data. Even as an intern, I had complete ownership of my project, and I appreciated the trust the company put in my abilities to solve a difficult problem. I learned outside of the office by analyzing core samples of the prospect I was evaluating. I also took a trip to our field in Utah to witness drilling, completions, and other oil field operations.

Overall, my internship with Newfield expanded my knowledge of the oil and gas business and operations and expanded my all-around geophysical skills.

Detecting UXO at Sky Research

James Gayer, Class of 2013

Of the various fields that one can enter into for Geophysics, Sky Research delves into one of the applications I am interested in: searching for UXO (unexploded ordnance) using time-domain electromagnetics (TDEM). Sky Research is based out of Ashland, Oregon, but works in several other locations on various major projects, including Boston, Hanover, Vancouver, and of course Denver, which is where I worked during the majority of the summer. On my first day, however, I was sent to Tennessee for two weeks to assist with a Research & Development project (or as Sky Research calls it, Science and Technology, or S&T). We went to over 1000 locations at which inert targets were purposefully buried, and we collected data on the responses of each one. It was awesome being able to actually interpret the relative locations of the targets based on the (graphical) conductivity responses. Assisting with this project also opened up the doors for a potential senior design project.

Kubota with towed-array of electromagnetic coils. Picture courtesy of Baraa Alrikaby, Sky Research

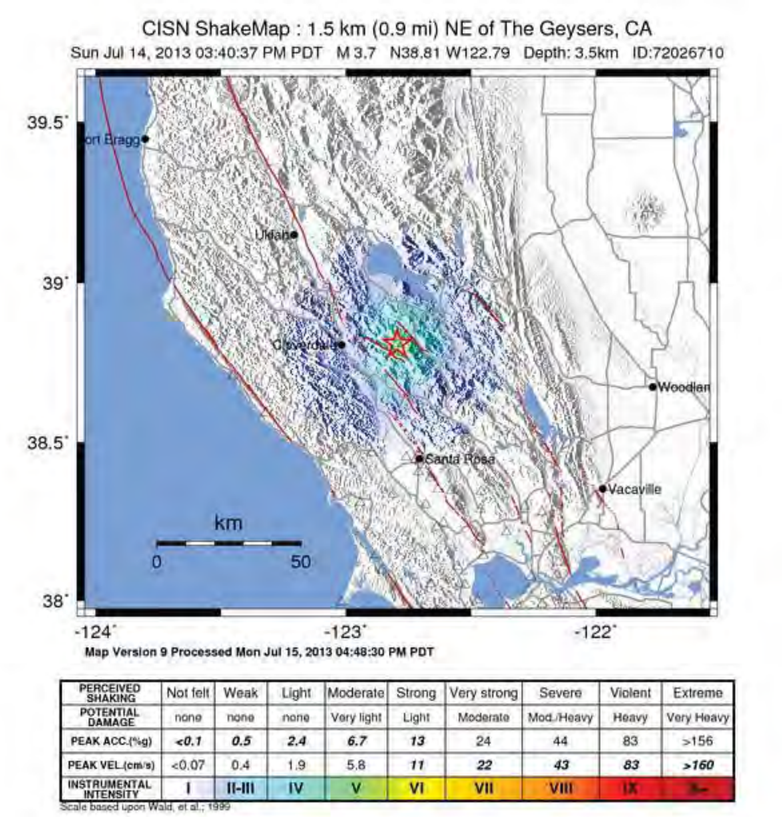
I spent the remainder of the summer at the old Lowry bombing range acquiring data and marking locations for buried UXO's such as fragmentation, shells, and occasionally almost fully intact missiles and small warheads (not nuclear warheads keep in mind). In addition to doing field work and improving my skills in TDEM, the team I worked with helped me become quite proficient in troubleshooting when the equipment developed problems. The problems could be as simple as the GPS accidentally turning off to having to rebuild pieces of broken equipment. Combining all of these skills, I really felt like a geophysical engineer, not just an intern.

Interning at the NEIC: Advantages of Working in a Scientific Community

Russell Mah, Class of 2013

For the past year and a half, I have interned with scientists at the National Earthquake Information Center (NEIC) branch of the United States Geological Survey (USGS). My job specifically has to do with creating an atlas of damaging earthquakes across the globe using software called ShakeMap, a standard way to display ground motion shaking due to an earthquake. I have been asked many times what I do, but I think people are probably more curious about my experiences working at the NEIC.

Like most interns, I arrived on my first day knowing little to nothing about what I was going to be doing. The first day was spent getting acquainted with the working environment, getting through the jumble of paperwork, and reading through papers (as well as some hands on guidance). My experiences were similar to any internship, except perhaps you get a few more papers to read as a researcher for training on problems, the software, and their components.



ShakeMap courtesy of USGS website

I didn't realize at the time that I could have walked down the NEIC hallways and talked to all the authors of the papers I was reading. I think that is really cool, to be able to discuss papers you find important with the people who wrote them.

The NEIC regularly has seminars scheduled on many interesting scientific topics, and not always about earthquakes. The lectures cover geomagnetism, hydrology, seismology, and many more interesting topics. I have enjoyed learning about a variety of things outside of my immediate interest or research. It is nice to be able to see what things people are doing in so many fields.

The people who work at the NEIC are sharp scientific minds, striving to be the best in their field. However, everyone is always willing to discuss scientific issues with you and supply data and ideas that you think might help. The environment is very laid back. To me this is a great atmosphere to work in, giving you lots of freedom and your work is based highly on your own drive. A great thing about geophysics is the variety of opportunities available for careers. Every geophysicist has the chance to get a job that inspires and supports them, no matter what their curiosities and preferences.

"High-Octane" Cimarex Energy — *Johannes Douma, Class of 2013*

Last summer I was given the opportunity to intern at Cimarex Energy in their Tulsa, Oklahoma office. I joined the exploration technology team for Mid-Continent. As Mines graduate, Ashley Fish, stated in a previous geophysics newsletter article, "Cimarex Energy is the definition of high octane!" However, I do not think this adequately describes their working environment. It is even more intense than that.

My supervisor for the summer was Mines alumnus, Dr. Steve Roche, to whom I now look for constant advice. He sat with me the first day to review four different projects that Cimarex wanted me to work on simultaneously. I did not understand anything about them and was concerned about what I had gotten myself into. However, in the next few days Dr. Roche taught me so much that I actually felt confident about working on them.

The first week didn't just end with a huge learning experience when it comes to geophysics, it opened up a whole new world for me in business. The first week I was allowed to join in the quarterly meeting. I quickly had to learn all the business abbreviations and jargons. I heard presentations ranging from the cost and production updates of building new pipelines to the current rates of return of wells. During this day-long meeting, each team presented their results to the CEO. One woman, not older than 28 years, was a reservoir engineer responsible for an entire region.

Throughout my internship, I was able to work with different industry experts on my multidisciplinary project. A rule that the leader of our Exploration Technology group constantly re-enforced was to over-communicate so as to not miss something. I was able to interact with some great petrophysicists, completion engineers, geologists and reservoir engineers to collaborate on my work and to be exposed to their knowledge and expertise in their field.

My internship passed by quicker than one could say, "finished". Throughout my internship I was asked to constantly update the company on my progress through almost weekly video-cam meetings with the Denver office, while the professionals in the Tulsa office join me in person. The interns are then asked to present to the CEO the final results of their projects. This was probably the highlight of my life. I was given 90 minutes to present to the CEO my results and maps. Now, the company is actually using my projects for their decision-making.

An Internship at Anadarko Petroleum Company

Chris Steinhoff, MS, Geophysics, 2013

Last summer I worked for Anadarko Petroleum Company in their Onshore Exploration group in Houston Texas. The primary goal of my project was to determine if a relationship exists between well productivity and natural fractures observed on 3D seismic data and use these conclusions to help drive the exploration opportunity available within a new basin. My secondary goal was to learn as much as possible about this Houston based company, its values and people.

I quickly adapted to the heat and soon discovered Houston is a great place to work, live and develop my career in the oil industry. Anadarko strongly believes in maintaining a healthy life-work balance and their 9/80 work schedule provided the free-time to experience much of what Texas has to offer. My mentor, and CSM alum (Ron Harris), has worked in the industry for 30+ years and had a special ability of creating fun in the workplace and during the learning process. During my internship, we traveled to observe the largest, most challenging 3D seismic survey that CGG is acquiring in the mountains of Pennsylvania. Later, traveling to Ohio we observed a 17-stage Utica "frac" job, open-hole logging, the collection of rotary cores and finally a zero offset vertical seismic profile (VSP). We also found time for a zip-line tour of the "The Wilds" in SE Ohio, one of the largest and most innovative wildlife conservation centers in the world. It was a great experience to see the wild animals with my colleagues.

In the end my experience with Anadarko was nothing but positive. It helped me build on the importance of teamwork and the value of good communication; as a result I was hired full time after completing my degree in 2013.

GRAIL Peers Inside the Moom ***(continued from page 11)***

to shed light on their formation. The biggest surprise, however, came in features that were previously unknown to science. A number of lineations emerged from the gradient maps, with lengths up to and exceeding 500 km. Inversion of the gravity anomalies reveals the presence of giant dikes deep beneath the surface.These dikes predate the geologic record on the surface of the Moon, and reveal an early epoch in which the Moon was expanding, with magma rising to fill cracks in the crust.

This high-resolution dataset is already revolutionizing lunar geophysics but the fun is just beginning. After the primary mission, the GRAIL orbits were lowered even closer to the surface for the extended mission. The spacecraft were practically skimming the lunar mountaintops, until they were intentionally crashed near the north pole of the Moon on December 17th 2012, ending the mission. The extended mission data is still being processed, but promises to hold even more surprises. Here in the Planetary Geophysics Lab, we will continue to mine this dataset to unlock the mysteries of the lunar interior.

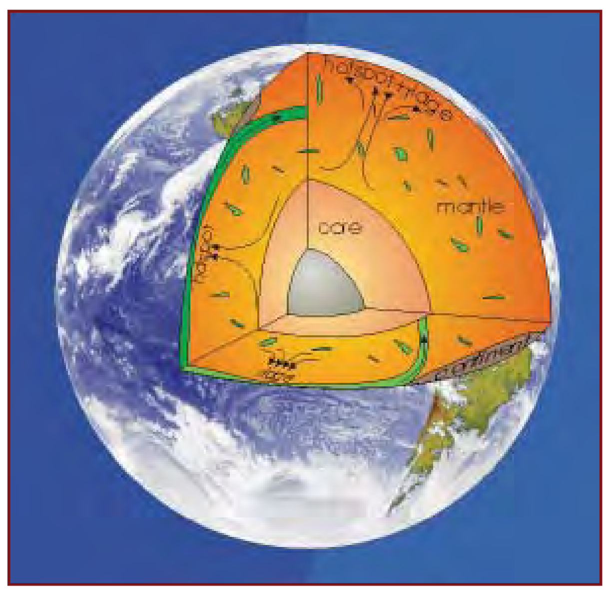
Geophysics to me...

Roy Bowling, Class of 2015

http://ascentum.com/wp-content/uploads/2010/06/planet-earth.jpg

Geophysics. The physics of the earth. 5.97219 × 10^24 kilograms of rock hurtling through space and we're along for the ride. Geophysics influences everyone every day. Our protective magnetic bubble displays light as it fends off high energy radiation at the poles, our lights turn on due to the oil reservoirs discovered through geophysical techniques, and the earth itself, the very ground beneath our feet, continues to move and change in an everlasting dance called plate tectonics.

That is what has drawn me to geophysics. I have always had a love of the earth, a fascination with mountains and canyons and rocks. And, I have also had a love of physics. The theories and principles that can accurately describe phenomena in our universe intrigue me. When I came to Mines and discovered geophysics I knew I had found the discipline for me. To be able to use such precise mathematical and physical principles to discover what is beneath our feet is amazing to me. And what is more, a geophysicist has the knowledge and technology to study the subsurface of the earth without excavating or actually digging into the ground. In particular geothermal energy is what interests me. Molten rock, a potentially sustainable resource for energy, is just beneath our feet. Our society is facing an energy crisis and I believe that with the tools of geophysics, we can solve the problem of sustainable energy. These ideas and more draw me to geophysics.



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Why Geophysics?

What My Geophysics Degree Means to Me

Bradley Wilson, Class of 2015

I was fortunate enough to have the opportunity to work for a human rights non-profit organization in Cape Town, South Africa last summer. During my experience, I was often asked what I was studying in school, and many were surprised to hear geophysics as an answer. The organization I worked for has over thirty interns, and not a single one was studying a science-related discipline, let alone geophysics. As I worked over the course of two months, I slowly realized just how many complex and interdisciplinary problems the world is facing. Geophysics may not seem necessary in the short term, but the practical applications of non-invasive imagery of the subsurface, including exploring for natural resources and groundwater, are becoming increasingly important as the global population continues to rise exponentially. Geohazard mitigation and smart infrastructure development in developing nations also tie into geophysical problems of the future. As a student with broad interests, a unique background,and a desire to address international issues from a scientific background, pursuing a technical geophysics degree at the Colorado School of Mines is a perfect stepping stone for becoming a global citizen committed to improving the future.

How-To When You Have No Clue

Anna Bond, Class of 2015

Last summer I had an internship with Golder Associates at home in Seattle, Washington. Each month growing up, my dad would bring me home a Golder Associates newsletter because he had clients and friends that worked for the company. Little did I know he was attempting to make me an engineer. I would flip through the pages and read about international mining projects or land developing projects or the coolest subsurface exploration projects. These newsletters sparked my interest in geophysics.

When the time came for me to get a summer job after my freshman year at Mines, my first choice was Golder. When I was accepted for the internship, I had no idea what it even entailed. I had never had a grown-up job before and I was scared to death! On my first day they immediately sent me to the warehouse of floor to ceiling shelves stacked with every type of instrument and tool imaginable. My boss handed me a large case and told me to go figure it out. I stared at him blankly for about 30 seconds and then realized I should probably “figure it out”. He handed me a magnetometer, which took me half the day to figure out how to set it up and operate. I spent the next six weeks repeating this process with different GPR instruments, almost every type of EM tool, and seismic equipment. After I played with the instruments and had a basic understanding of how they worked, Golder asked me to write How-To guides for new employees that did not know how to operate the equipment. Teaching people how to do geophysical surveys with tools that I had never seen before was a challenging experience, but it taught me that I am capable of much more than I ever imagined and that geophysics is the coolest thing on (or perhaps, under) the earth!

Geophysics?

Christian Feagans, Class of 2015

At the age of 5, I wasn't much different than any other little girl. I enjoyed playing with Polly Pockets, dressing up and watching a good Disney movie. While I enjoyed all of these activities typically done by little girls, I also enjoyed a few things which weren't so girly. I was the little girl who came home with rocks in her pockets almost daily- there wasn't anything particularly special about these rocks that I brought home, but if one caught my eye it would find a new home in my pocket.

As I got older, I realized that I was not only good at math, but I also enjoyed it a lot. In high school, and being from Colorado, it only made sense that after graduation I would end up at the Colorado School of Mines, so here I am! Coming into Mines I wasn't quite sure what I wanted to do though. Sure, I like rocks, and yeah I'm pretty decent at math, but constantly looking at rocks or writing out equations was not for me. I wanted more, I wanted to be able to problem solve. Geophysics seemed to fit what I was looking for. While I am still very young in the Geophysics department I am looking forward to what I can get out of this field.

"It Was Always Geophysics"

Rose Leone, Class of 2015

Moving 2000 miles away from home is definitely one of the harder things I've had to experience, but Colorado School of Mines made it easy. I instantly fell in love with Colorado, the friendly atmosphere in Golden, and the beautiful foothills that rise over the campus. When I came in as a freshman, there was no question of what my major was going to be; it was always geophysics. Geophysics is the only major that encompasses everything I love to study: physics, geology, and most importantly space. When people ask me what I want to do with my major and I tell them my life goal is to discover life on other planets, they usually just give me some bizarre stare. I even remember when a geophysics professor overheard me when I first walked into the geophysics office as a freshman. When I said I was interested in planetary geophysics he told me: "So you're going to be broke and happy one day?"

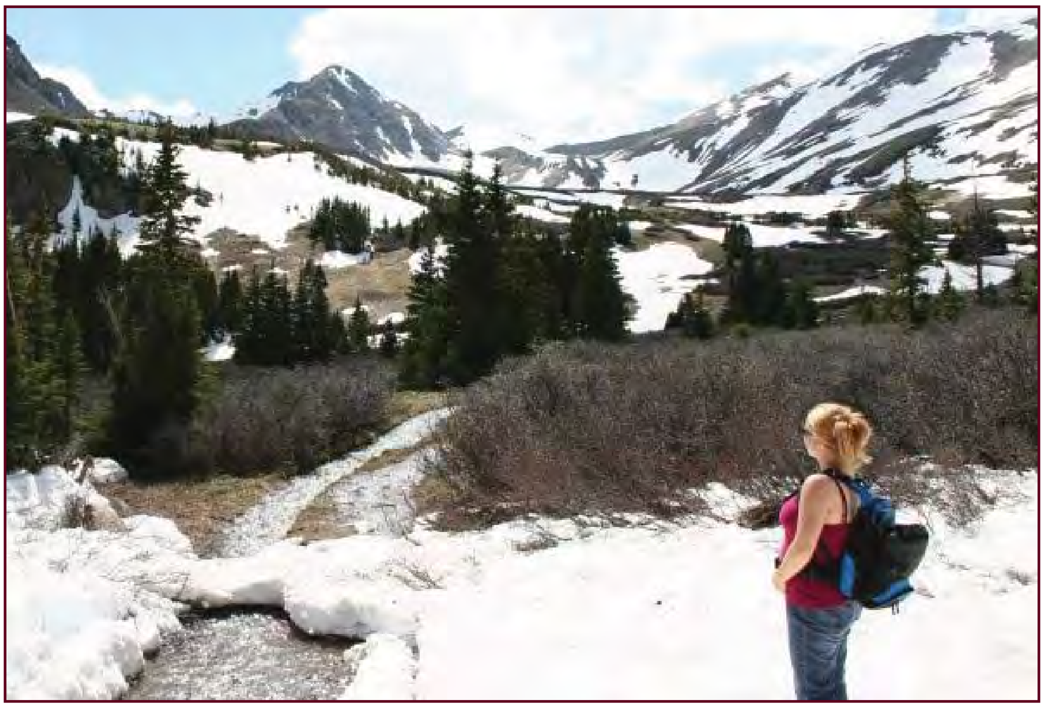
One of the reasons that I am so drawn to planetary geophysics is that we can compare the geology of unknown planets to our planet. By doing this we can check for signs of water and study processes that happen on other planets that are nothing like what happens on earth. Even on the moon, we see science that is nothing like what we see on our planet. Recently, soil scientists were able to look inside gas bubbles from lunar soil samples using a technique called synchrontron-based nano tomography. Instead of finding gas or vapor inside the bubble, the scientists found extremely glassy-looking porous nanoparticles that surround the interior of the bubble. This explains why lunar soil has many unusual properties.

Being able to study geophysics on this planet is great, but the fact that I have the opportunity here at CSM to extend that knowledge across the universe amazes me. Don't you ever wonder what's out there?

The Beauty of Colorado

Tiffany Lane, Class of 2015

Colorado is my home state and I am proud of it. I was born in Denver, Colorado, and grew up in Arvada and Golden. I have spent my life in Colorado fishing, camping, backpacking, skiing, snowboarding, mountain biking and hiking. The Rocky Mountains of Colorado contain some of the most beautiful sights I have ever seen. Spending so much time in the mountains has turned me into an avid Earth lover. The feelings that you get from going out and being with nature are indescribable, especially when you can be alone. I am fortunate to have been born and raised in a state that people will spend hundreds to thousands of dollars to vacation in. I have always dreamed of being able to be a part of preserving this beautiful area, and with an increasing population, this dream seems to become less and less of a reality as we move towards the future. Population increases mean more demands for resources and energy, which threatens the natural beauty of our state. Mining exploration tends to damage Colorado's beautiful Rocky Mountains and produces acid mine drainage. Wind energy is a great option for renewable energy, but the sight of wind turbines streamed across our beautiful mountains can take away from the aesthetics of the view, which is a common complaint among the general population.



My dream of keeping Colorado beautiful is what made me decide to go into geophysics. It was the dream of being able to preserve our beautiful state, while still being able to match the energy demands of our growing population. As a geophysicist, I would be able to do research and exploration in the field of energy, mainly in how to extract fossil fuels and natural gases from the earth in a safe and clean manner. Renewable energy is important for our future, and will hopefully be what eventually replaces fossil fuels, but fossil fuels will still be an energy source for our planet for a long time. To extract and manufacture fossil fuels responsibly, it is important to work carefully to avoid leakage and contamination of the surrounding environment. By getting my Bachelor of Science degree in Geophysical Engineering from the Colorado School of Mines, I hope that one day I can be a part of a team that is working towards the goals of having safe fuel and energy extraction so that we and future generations can still enjoy the beauty of Colorado and other areas of the world.

Geophysics 2012 Field Camp - Pagosa Springs, Colorado

It all happened when a generous invitation was sent to the geophysics students and faculty of Colorado School of Mines by the city of Pagosa Springs, Colorado. Subsequently, this town was targeted to be the destination of the annual field camp for the 2012 junior class of geophysics. It was a four-week journey divided into two weeks of field work and two of data processing. This was an essential experiment for us where all the written material of the core classes came to life in a mission of characterizing the water resources in Pagosa Springs. With the assistance of the professors and the teaching assistants, we were able to conduct various geophysical surveys at different sites, including magnetic, electromagnetic,seismic and gravity. Every morning, the students were divided into groups with different tasks so that everyone could have the chance of working with all the survey types. After cross sections were completed and many data were acquired, it was time to go back and start processing. It felt good to see interesting results with different interpretations, which all tightened up into our final report. Such an experience was definitely beyond my expectation; the people I met and the information I gained are what made this trip so precious. ***Hala AlQatari***

Hot-water, sulfur, frustration, shale, bears, blisters, pyroclastic bombs, hikes, memories, deep seismic crews, British buddies, and satisfaction. Geophysics involves all of these topics among others which keep life interesting. This past summer geophysics escalated to another level of "interesting" during field camp in Pagosa Springs, CO. Ask any of the Mines seniors, Imperial College students, or faculty that attended and they will likely concur that the field camp was a great success. Our aim for field camp was to characterize the geothermal system near Pagosa Springs. We managed to collect a large variety of datasets including gravity, magnetics, EM, DC resistivity, IP, self-potential GPR, deep-seismic, hammer-seismic . . . the list goes on. Acquiring the data provided the students the opportunity to experience data acquisition on a larger, more realistic scale than Kafadar Commons. The experience no doubt modified how I view geophysics and my career. Besides the educational and practical aspect of field camp, it is worth noting more than just wavelets or voltage readings were attained. Specifically (I speak for myself, and perhaps hopefully others), friends were gained. Not the quiet distant friends that you met in Materials of the Earth sophomore year, but the friends that night-hiked at Chimney Rock with you, hauled DC cables up mountains with you, and stomped geophones with you. It is rare to find friends that feel so passionate about geophysics. There's no friend like one that can converse with you over hot springs, bear-hunting and French faults all in the same sitting. It may seem insignificant, or perhaps, trivial when you are out sweating, grunting, and hiking in the treacherous fields of Zen Garden, but with time the memories made in field camp become valuable. ***Thomas Rapstine***

Field Camp, the most important and fun time any geophysics undergrad will have at Mines! Although we love studying on weekends and late hours in the Linux lab, theory, paper, pencil, and computer screens, we can only learn so much inside the castle-like walls of the Green Center. Participating in field camp hosted by one of the best geophysics programs in the world provides us with a unique and invaluable opportunity to learn our trade in a hands-on and enjoyable way. Through all the hard work and heat, we power through, and come back home with the greatest reward a student could ask. Yes, carrying 50-pound cables and long days in the sun are hard, but the camaraderie and knowledge we come back with are second to none. We are unlike other departments at our school, where field camp merely consists of orchestrated lab exams and graded mapping exercises at the same locations year after year. In geophysics, we get to go out to fresh new locations, trying to solve real-world problems which have never been looked at before. The icing on the cake, is getting to help communities in the process. I don't think one could define a greater win-win situation for students, faculty, and communities alike. In the end, we come back home to the campus with our newfound knowledge to continue our studies with data reduction, processing, and interpretation in effort to compile the culmination of our experience in a comprehensive geophysical report. Though we have theory classes, methods classes, and programming classes, no one experience puts the story together of what it means to be a geophysicist better than summer field camp. Now we enter senior year with a newfound drive and direction to point us on our way. Whether grad school or industry is your path, nothing prepares you for the road ahead better than geophysics summer field camp.

Matthew Emmett

Hawksbill Turtles and GPR
Georgianna Zelenak, Class of 2013

In September I had the incredible opportunity to travel to Maui to complete the field work portion of my senior design. The idea of the project was to locate Hawksbill turtle nests quickly and in a non-invasive manner using ground penetrating radar. Accurate location and protection of the nests is crucial for this critically endangered species since females tend to lay their eggs on popular tourist beaches with heavy traffic.

Current conservation efforts rely on volunteers walking along the beach every morning at dawn looking for turtle tracks leading towards a “pit”, or area where sand has been excavated. Once a probable nest has been located the area is taped off and checked daily by volunteers. As the incubation time comes to a close the monitoring efforts increase, with a dedicated group of turtle enthusiasts and biologists watching the nest around the clock for two weeks leading up to the expected hatch date. This method of locating the nests is less than ideal as wind, waves, and human activity can easily erase the tracks. Even if the tracks

are still present it can be exceedingly difficult to accurately locate the nest. Nesting females tend to dig multiple pits in a given area and will wander about a bit before returning to the water. This is all wonderful for confusing potential predators, but unfortunately it is also confusing for the well-meaning volunteers who are trying to protect the young turtles.

In the course of a week we collected data over four active nests as well as multiple nests that hatched last year. We encountered a number of challenges such as excessive amounts of trash (including rusted out cars) on the beach and tree roots throughout the area. In the case of a nest that was hatching at the time of our survey we had to lift the GPR equipment over the spot in order to avoid putting any weight on the hatchlings. All of this taught me valuable lessons on how to adapt to unexpected

conditions in the field. Hopefully, despite the challenges we were able to successfully pinpoint the locations of the active nests. The youngest nest we surveyed should hatch around Thanksgiving, and at that point biologists will contact us with the true locations. With any luck we will be one step closer to finding a system to locate turtle nests without the time-intensive volunteer work daily. Regardless of our results, there is much work to be done on this project and hopefully students in the future will have this same incredible opportunity for their senior design.

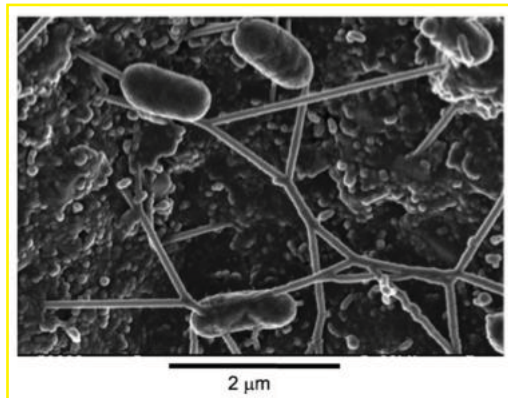
Biogeophysics. What? ... BIO-GEO-PHYSICS

Arantxia Gallastegui, Class of 2013

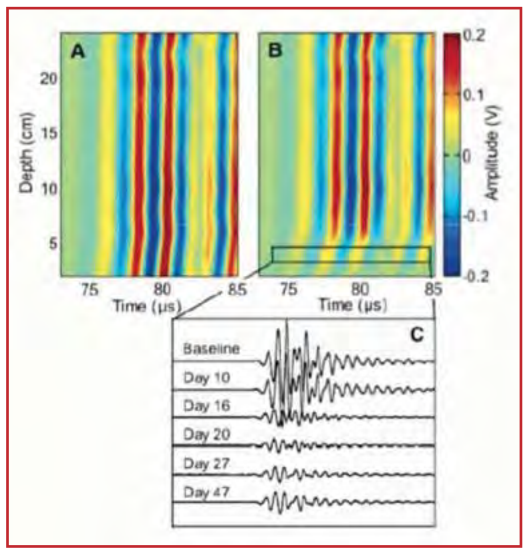
In case you did not know, now we can add a "BIO" to our smart looking name: Biogeophysics. And we can do it thanks to holes inside the rocks, that is, porosity, a key petrophysical parameter that can affect geoelectrical and seismic measurements. Thanks to studies in groundwater geochemistry, we know that microbial metabolism and growth can lead to a secondary porosity through the dissolution of different mineral phases. This can cause a clogging of the porous medium and change the porosity and hydraulic conductivity. Biogeophysicists combine the fields of microbiology, biogeoscience, and geophysics to study the links between dynamic subsurface microbial processes, microbe-induced alterations to geologic materials, and geophysical signatures. They try to answer questions about the geophysical signatures of microbial cells, the best geophysical methods to understand microbe-mineral transformations, the usefulness of geophysics to improve our understanding of biogeochemical processes, and, among many others, the chances that geophysics can contribute to the exploration of microbial communities in extreme or even extraterrestrial environments.

There are at least six geophysical methods that have been adopted for biogeophysics research: 1) electrical resistivity, which measures electrical potential generated by current injection and has been applied in biodegradation; 2) ground-penetrating radar that measures the amplitude and arrival time of electromagnetic energy and was used to study biomineralization and cell properties; 3) induced polarization, which measures decay in electrical potential following current pulse and has been applied to study biomineralization and cell properties; 4) magnetometry, which measures magnitude and/or gradient of Earth's magnetic field and has been used to study magnetotatic bacteria; 5) seismic, which measures the amplitude and arrival time of elastic energy and was utilized for bioengineered soils and biogenic gasses; and finally, 6) spontaneous potential, which measures naturally occurring electrical potential and has been used to study biogeobateries and biodegradation.

Biogeophysics – certainly a mouthful. But if you get just one thing from this article, it is that whenever you think of geophysics, think that a lot of this business of science and engineering is about breaking the molds and looking beyond. You can get a nice engineering job out of Mines, but expand your horizons - it could also be a stepping-stone toward something you never thought of before. It all comes down to curiosity and lack of fear. Who knows, maybe one day when someone asks about your major or field of study and you will reply Bio-geo-physics!



*SEM images revealing geopili linking cells to cells and to mineral surfaces, suggesting electrical "hardwiring" of a soil column **



*Experimental evidence of attenuation of seismic waves as a result of biomineral formation **

** Atekwana, E. A., and L. D. Slater (2009), Biogeophysics: A new frontier in Earth science research, Rev. Geophys., 47, RG4004, doi:10.*

My Summer as an Undergraduate Research Assistant

Jarred Eppehimer, Class of 2014

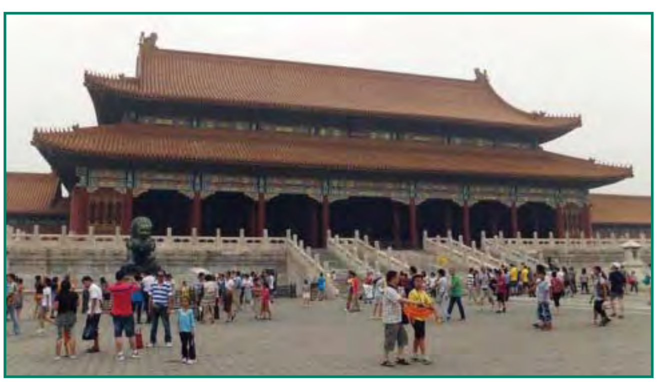
Last summer, I decided to stay in Colorado rather than go home to Louisiana. Beside avoiding the blistering heat and humidity that goes with Louisiana summers, I really wanted to see what geophysics-related work I could do right here on campus. I was fortunate enough to be offered a position as a research assistant working under Prof. Andre Revil, starting immediately after school ended. The project involved characterizing electrical properties of clay-rich saprolite samples collected at the Oak Ridge Integrated Field Research Challenge Site, Tennessee. I primarily worked in a lab in the Green Center basement with a postdoc, Magnus Skold. My days consisted of making large quantities of solutions to flush through our saprolite samples, monitoring the effluent flow from these samples, and taking lots of notes. Once the samples reached equilibrium with their current flushing solution, we were able to measure things like complex conductivity and streaming potential. Although things in the lab could get dull at times, I really enjoyed working with Magnus and Dr. Revil. Also, I was able to essentially set my own schedule most weeks, which was great. By the end of the summer, along with what Magnus had already been working on, we had collected and organized enough data for Dr. Revil to include our research in two papers! These will be my first publications, so I am excited about this outcome of my summer research. I am very glad I was given this opportunity, and I highly recommend it for any up-and-coming undergraduate geophysicists.

McBride Foreign Area of Study 2012: China

Stephen Cuttler, Class of 2013

One of the unique advantages of the McBride Honors Program is its annual foreign study involving both classroom work and foreign travel. Last summer we traveled to northern China on a scientific and cultural journey rarely found in the Mines curriculum, coordinated by Dr. Carl Mitcham of LAIS and PhD students Wang Nan and Zhu Qin. Our trip was divided primarily into two parts. We began in the port city of Dalian, spending two weeks attending classes at the Dalian University of Science and Technology. There we built up our proficiency in basic conversational Mandarin as well as beginning written Chinese. We learned about traditional Chinese philosophy from Dr. An Yaming, head of the foreign language department at Clemson University, focusing on such great thinkers as Confucius (Kongzi), Maozi and Zhuangzi. We were also treated to a class on Chinese calligraphy, not taught in English. We engaged in discussions with Chinese and Belarus students comparing American and Chinese cultures and societies, focusing on the modernization of both countries and how both countries will progress into the future considering resources, national infrastructure, and cultural change. We traveled all around Dalian, experiencing modern Chinese life and learning that even an ocean apart we really are not all that different.

The second half of the trip was a whirlwind. We departed from Dalian via ferry and crossed the Yellow Sea, spending the night in Yantai. We departed by train the next day for Yanzhou and Qufu, ancestral home of Confucius and the largest Confucian temples in the world. We traveled by bus to Tai'an, where we climbed the holiest mountain in China, Tai Shan. We then traveled by bullet train to Beijing where we spent our final week visiting the great sites of the city: Tian'anmen Square, the Forbidden City, the Great Wall, the Summer Palace, and the Olympic Park. We also spent time at Tsinghua University discussing Chinese infrastructure with civil engineering students. We explored the city, meeting interesting and friendly people and trying cuisine not found on this side of the Pacific. All the while we observed Chinese society first-hand for a truly a unique and insightful investigation.



A Year in Europe

Bren Malcolm, Class of 2014

Last year I had the opportunity to take a year off from my math, science and geophysics studies at Colorado School of Mines and spend a year abroad in Bilbao, Spain. I attended the University of Deusto in the Basque region. Located just minutes from the Bay of Biscay, a couple of hours from France, and the Pyrenees Mountains, the Basque Region is a beautiful and geologically varied place. Bilbao boasts the impressive and "other-worldly" Guggenheim Museum, a winning Fútbol team and an engaging and passionate culture.

In addition to language classes, I studied Spanish culture, gastronomy and literature. I was most intrigued with my classes about Spanish and European politics, especially the role of Spain and the European Union and their role in the world. My classmates haled mostly from California, Chicago, and New York. Being one of the only westerners and engineering majors, I did my best to represent Colorado and CSM. The señora with whom I lived taught me about Spanish cooking and my hall mates in the dorm included me in all of their traditions and fun. As well, my time abroad turned me into a connoisseur of all things Spain: wine, cheese, fútbol, nutella and cathedrals!

During my year, I was able to snowboard the Pyrenees, surf in the Bay of Biscay, hike the Swiss Alps and travel throughout Spain, Portugal, Italy, France, Germany, the British Isles and Denmark. Although my studies were not focused on science and technology, my year away has given me a new and unique perspective on and appreciation for life, and my role as an engineer. I hope to use my Spanish language skills, knowledge about the world and Mines education to contribute to the world. ¡Gracias Mines and the Department of Geophysics for allowing me this opportunity!

Toldeo, Spain

Guggenheim Museum, Bilbao, Spain

Rome, Italy

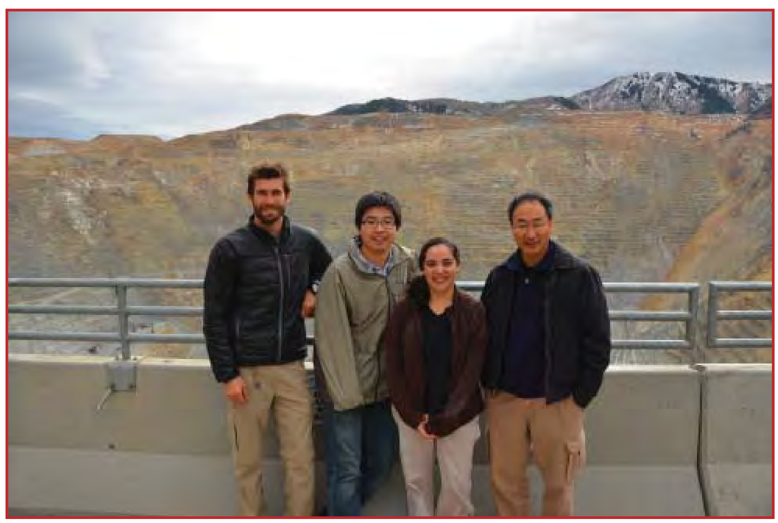
My Experience as a Visiting Scholar at Mines

Terry Kratzer, RMIT

Collecting hammer seismic data at field camp.

I'm a PhD student at Royal Melbourne Institute of Technology University (RMIT), studying under Professor James Macnae. I was a visiting scholar at Mines for the Fall 2012 semester. where Professor Yaoguo Li hosted me in the Center for Gravity, Electrical and Magnetics(CGEM). My experience was very rewarding – it's great to work in a group like CGEM where there is a diverse range of interests and skills among students and staff. Thanks to Professors Terry Young and Yaoguo Li, I was also fortunate to participate in the Geophysics field camp over summer. Prior to field camp I'd had limited field experience, so the introduction to a wide variety of geophysical methods was both fun and invaluable to my professional development.

CGEM also provided assistance for myself and other students to attend a field trip to three different operating mines in Utah and Nevada and speak at the SEG conference in Las Vegas, giving us exposure to geophysics in the commercial world and a wide range of current geophysical research and professional contacts respectively. Having a background in engineering and physics has often been very helpful but it also means that I have limited knowledge in some specific geophysical techniques, as well as geology. While here I had the chance to audit a number of graduate courses in Geophysics and Geology.



Touring Bingham Canyon Mine, Salt Lake City, Utah, with grad students Jiajia Sun, Cici Martinez and Professor Yaoguo Li

I also enjoyed the great outdoor life that is Colorado – mountains, hiking, snowboarding – I definitely miss it since returning to Australia!

Although some fellow students have seen it appropriate to remind me often that my Australian spelling and pronunciation of certain words is wrong, and that my perception of what constitutes cold weather is wrong, and that not driving on the right side of the road is wrong, I really enjoyed the positive and enthusiastic culture in the Geophysics department and in CGEM in particular. It has probably been the thing that has struck me most about studying at Mines. Thanks to everyone I met at Mines for a rewarding and enjoyable experience.

"Hike for Help" in Nepal

Allie Grazulis, Class of 2013

During the summer before my junior year at Mines I had the opportunity to go on an incredible trip halfway around the world. Lhakpa Sherpa, the owner of the Sherpa House restaurant near campus, wanted a group of Mines students to travel with him to his home of Nepal. His goal was to help the people of his village begin building a trail that would connect to a village on the other side of the mountain. This path would help cut down travel time for the local villagers who needed to walk great distances every week in order to exchange food and other supplies. In the 2011 spring semester, Lhakpa recruited 14 students, myself included, who were eager to make this great journey. This trip was part of an organization called "Hike for Help".

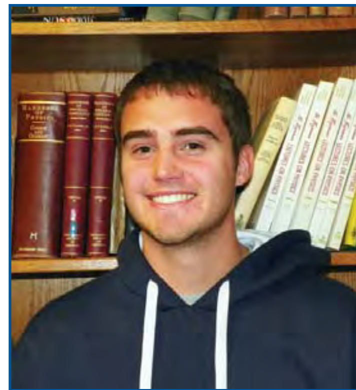
The trip was unbelievable. We first flew into Kathmandu, the capital of Nepal, where we immediately encountered a culture shock. The city is full of rich Buddhism and Hinduism culture, with many famous and historic buildings, but Kathmandu is also full of poverty and despair. Despite the negative issues we encountered, there were many exciting attractions. We visited historic, religious temples and saw many interesting sights, including cows wandering the streets downtown (cows are holy and therefore untouchable in the Hindu religion).

The main part of our trip began when we flew north of Kathmandu, into the Himalayas, to a village called Lukla. The mountain villages are a completely different world than the hectic city of Kathmandu. As soon as I stepped off the plane I could feel a kind of serenity and calmness in the air. Everything was so green, there were streams everywhere and the mountains were larger than I had ever seen. Prayer flags hung everywhere made the village dance with color. There were no cars or any kind of vehicles. All traveling was done by foot or animal.

The people seemed very relaxed and friendly and we immediately felt welcomed. We spent the next few days hiking from village to village across Sagarmatha National Park (Mt. Everest National Park), until we reached Lhakpa's home where we would start working on the trail. Our labor consisted of things like cutting into the mountain, digging out dirt and clearing brush away. We worked on the trail for about five days; getting acquainted with the locals as much as possible. We got a great start on the trail and I recently heard from Lhakpa that the trail is just about complete.

I am so grateful I had the opportunity to be part of such a special experience. Not only did I learn about lifestyles and cultures much different from our own but I made long lasting friendships along the way. "Hike for Help" is a great organization and I wish more people have the opportunity to experience it.

Reflecting on My Freshman Year
Isiah Leyshon, Class of 2016



My name is Isiah Leyshon and I was born and raised in Thornton, Colorado. In high school I didn't know what college I wanted to go to, and I was lost in career choice as well. My first knowledge of the Colorado School of Mines came in a letter I received at the beginning of my senior year in high school. Enclosed was a free application to Mines that didn't require me to write an essay. I thought to myself, "Any school that doesn't ask for money or an essay is worth applying too!" After filling out the essay and mailing it in, I began to research the school and learned that it was by far the best school in Colorado. The Colorado School of Mines is a world renowned engineering school specializing in the earth, energy, and the environment, and graduates from the school land incredible jobs. A few weeks later, I learned I was accepted to the school. Needless to say, I was ecstatic that I would be attending Mines. My freshmen year at Mines I learned more about math, physics, science, and myself than I had my whole life. This school challenged me in ways I never thought possible. Mines made me study for hours on end in the library, only to get a 55% on a test. Mines taught me how to get up and keep pushing after you just fell down. It taught me that it's ok to get the question wrong because you learn from your mistakes. I learned that there are so many people who are much more intelligent than I am. This school educated me on how to balance school, family, and friends. But most of all, I learned that in order to succeed at this school, or at anything great, you have to push yourself, get out your of your comfort zone, and try harder than you ever imagined. I feel that completing my freshman year was one of the greatest accomplishments of my whole life. Now in my sophomore year at Mines, I know what this school expects of me and how I have to perform to do well. If I could tell incoming freshmen a word of advice it would be get rid of their hubris and prepare to try harder than you ever had in your whole life. As long as you do that, I believe you will do just fine here at the Colorado School of Mines.

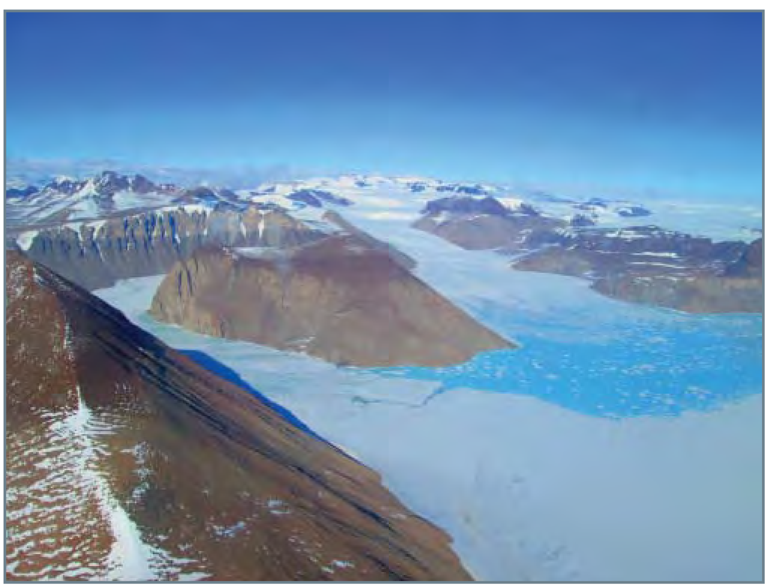
Right: Professor Paul Sava prepares for his sabbatical

Left: GP intramural track team

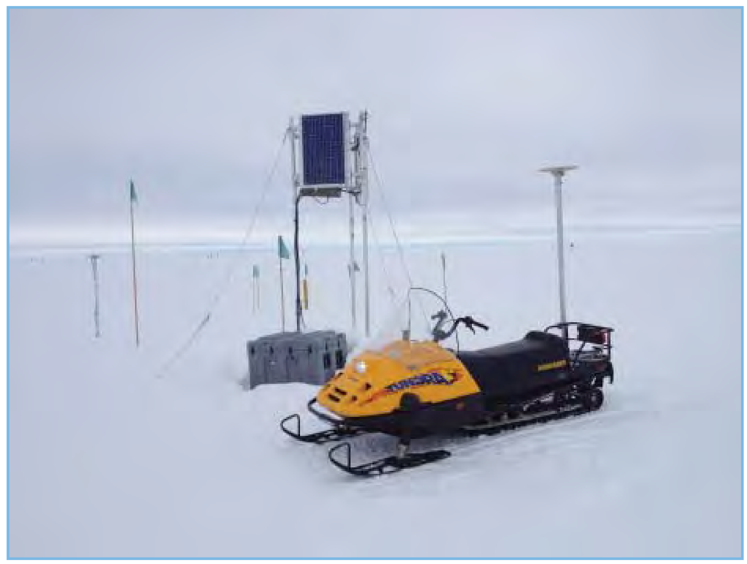
My Year With UNAVCO

Travis Pitcher, Class of 2012

Since graduating with my B.S. in Geophysical Engineering in May 2012, I have been employed as a Field Engineer with UNAVCO, Inc. UNAVCO is a non-profit university-governed consortium that facilitates geoscience research and education using geodesy. Primarily, this position has been in support of the Plate Boundary Observatory (PBO) – the geodetic component of EarthScope. Working from a satellite office in Southern California, our team is tasked with the installation of new geodetic stations, as well as general operation and maintenance of the existing 1200+ station network. This requires extensive travel to remote regions of the globe, and many hours logged behind the wheel of our trucks. Additionally, the job requires both an intellectual and technical acuity that allow you to work with many types of geophysical instruments while being keenly aware of the geological target.



UNAVCO is a fairly small organization so there are many opportunities to lend aid to other divisions who find themselves short-staffed at certain times of the year. In my short time with the company, I have had the pleasure of working in California, the Pacific Northwest, Alaska, and Antarctica. During the 2012-2013 winter, I spent a total of two months in a remote field camp located in western Antarctica working as the project engineer for POLENET. This geophysical network is spread across most of the continent, and has both a geodetic and seismic component, operated by engineers from UNAVCO and PASSCAL, respectively. All field operations were extremely weather dependent, as each site visit required the use of a Twin Otter or a helicopter. We saw temperature extremes ranging from -50 to 40 degrees Fahrenheit, all the while living out of our North Face tents in the snow. During the summer of 2013, I joined members of our Alaska office in multiple field trips based out of Kodiak Island. This required the daily use of a helicopter, and took us all over the Aleutian Chain, and to locations such as Katmai National Park and Preserve.



This fall, I will rejoin the CSM Geophysics department as a Master's student with the Reservoir Characterization Project. Over the last year, I have constantly been reminded of the caliber of education I received during my undergraduate career at Mines. No other program could have prepared me so well for the rigors of such a unique geophysical career. My time spent as an engineer with UNAVCO was exciting and invaluable, but I am very much looking forward to earning my Master's degree and exploring the opportunities ahead.

Class of 2012

Doctor of Philosophy (Geophysics)

May 2012:

Dr. Mason Andrew Kass (center) with Department Head Terry Young and advisor, Dr. Yaoguo Li

December 2012:

Dr. Xiaoxiang Wang (center, left) with his advisor, Dr. Ilya Tsvankin (left); Department Head Terry Young (center); Dr. Yong Ma (center, right) with his advisor, Dr. Dave Hale (right). Not pictured: Dr. Clement Fleury

Master of Science (Geophysics)

May 2012:

Mohammad ElBaharia, Ahmad Ramdani, Leslie McWhirter, Jeff Godwin, Assem Bibolova, Margarita Zyrianova Not pictured: Holly Robinson, Saksit Sa-Nguanphon

December 2012:

Conrad Newton, Antonio Velasquez, Xinhui Min, Andrea Vega; ***Professional Master (Petroleum Reservoir Systems):*** *Travers Boughdadly, Obi Ehi, Cornilius Ndifor. Not pictured: Ashley Fish, Jesse Havens, Yser Kattoum, Sean O'Brien, Isabel White*

Bachelor of Science (Geophysical Engineering)

May 2012: *(rear) Megan Sprot, Travis Pitcher, Gordon Osterman, Matthew Fackler, Nicholas Kramer, Joseph Capriotti, Camriel Coleman, Jamie Clifton, (front) Kendra Johnson, Chelsea Newgord, Patricia Littman, Bethany Behrens, Meghan Helper. Not pictured: Banks Beasley, Kelly Zimmerman*

December 2012:

Norah Al-Dossary

Department of Geophysics
Colorado School of Mines
Golden, CO 80401-1887

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Congratulations Michelle Szobody!

Bachelor of Science
Engineering
Mechanical Specialty

Colorado School of Mines

Class of 2013