

geophysics

Colorado School of Mines

Summer 2012



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- 4 Gary Olhoeft
- 7 Faculty & Friends
- 8 Graduate Students
- 12 CWP
- 14 RCP
- 16 CGEM
- 18 Hydrogeophysics
- 19 Edwin Nissen
- 20 Planetary Lab
- 22 Distinguished Science
- 24 Colorado is Special
- 25 Date an Earth Scientist
- 26 Student Life
- 28 Why Geophysics?
- 32 Field Camp
- 34 Study Abroad
- 37 Senior Design
- 38 Internships
- 44 Class of 2011
- 47 AGU

From the Department Head

Warm greetings from the Department of Geophysics!

We are glad our departmental magazine (it's gotten too large to call it a newsletter anymore!) has found its way into your hands. The diverse articles and photos are a small sample of the many people and activities that enriched our year in Geophysics.

For us, it's all about people! So we celebrate the life and career of Gary Olhoeft, who just retired after 17 years on the CSM faculty. We are grateful to add Tim Collett (USGS) to our adjunct / affiliate faculty. And we look forward to welcoming earthquake seismologist Ed Nissen, who joins our faculty in August. Meanwhile, we have a search underway for a new faculty member with broad expertise in electromagnetics.

We are bursting at the seams in the Green Center. In the past 4-5 years our student enrollment in Geophysics has doubled from about 50 undergrads and 50 graduate students to 100 of each. And we continue to welcome large numbers of visiting scholars, who collaborate with our faculty and research groups. So, we are out of space. We are also at the end of the service life of the roof on the Green Center, so we look forward to a new

On the cover

Seniors Meghan Helper and Kendra Johnson and graduate student, Lillian Comegys, take a break from stringing geophones at Geophysics field camp, Neal Hot Springs, Vale, Oregon, summer 2011.

building one day soon!

In Fall, we received a thoughtful, upbeat review of our department by the External Visiting Committee, which included Rutt Bridges (Transform Software and Services), Richard Degner (Global Geophysical Services), Perry Eaton (Newmont Mining Corp.), Erec Isaacson (ConocoPhillips), Jerry Harris (Stanford University), Alan Levander (Rice University), and Jill McCarthy (USGS). We are grateful for this enormous contribution by these distinguished colleagues.

Our field camp continues to be the capstone experience and highlight for most undergraduates. Last summer we were joined by Boise St. University (under the leadership of Kasper van Wijk) and Imperial College, London (under the direction

of Helmut Jakubowicz), as we applied a vast array of geophysical techniques to the characterization of the geothermal system at Neal Hot Springs, Oregon. In summer 2012, we were guests of Pagosa Springs, Colorado, where we will conduct a similar field exercise accompanied by Imperial College students and faculty. We are grateful for the many contributions of expertise and resources that make this camp a success year-after year. In particular, we thank Sercel, for the new seismic recording system (thank you, George Wood!), CGGVeritas, for the vibroseis systems and crew, and Mr. and Mrs. Richard Degner for their financial support.

Enjoy!



Look for Us at SEG!

The Department of Geophysics Alumni Luncheon at SEG Las Vegas 2012 will be held on Tuesday,

November 6, 11:30am. For more information, please

see Michelle Szobody at the CSM booth, #2402, in the Shorelines A section of the exhibit hall, or contact her at mszobody@mines.edu.

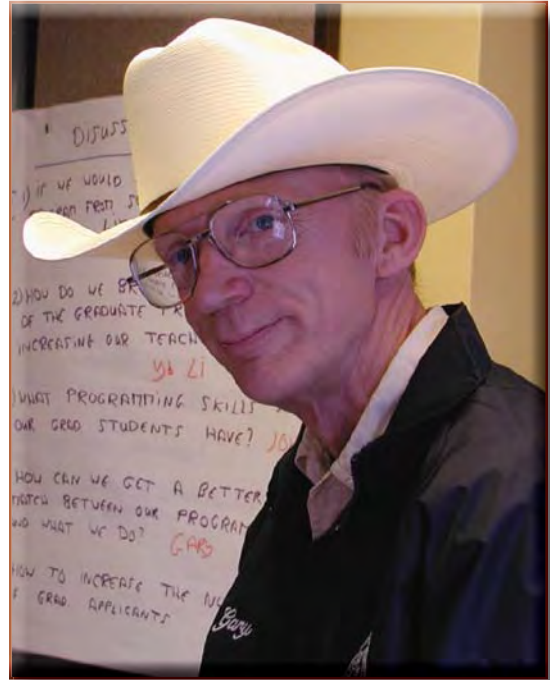
Thank you to BP and Shell for providing funding for the 2012 Geophysics magazine and to all of our sponsors for their continued support of the department!

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

DRINKING FROM A FIREHOSE

A Tribute to Gary Olhoeft

Gary Olhoeft retired from the faculty this past year. His retirement marks the end of an era in which every undergraduate was initiated into the Geophysical Engineering program by taking “Gary’s course” -- GPGN210 Materials of the Earth. When Gary retired, we also retired Gary’s signature course. It’s a bit like retiring the jersey (numerals) of the perennial MVP on a sports team. How do you fill the shoes of someone whose labs have titles such as “Bubble in Straw 1”, “Bubble in Straw 2”, and “Poisson’s Ratio of a Marshmallow”? Students described Gary as the “man of 1000 viewgraphs.” They were captivated by his lectures, fascinated by the breadth and depth of his knowledge, impressed by his intellectual quickness, and overwhelmed by trying to take notes while drinking in new information from a firehose.



Gary joined the CSM faculty in 1994. He brought to CSM a wealth of experience from his prior work with NASA and the USGS, along with some unique vacuum chambers and other experimental devices. He loved to teach and found it hard to say “no” when, in addition to his regular load, his graduate students asked him to teach courses on a wide variety of *ad hoc* topics. When students evaluated his teaching they always remarked on the unique and valuable experience of having been in his class, noting that he “really made them think for themselves.” In addition to the technical subject matter, he insisted that students learn the right way to keep lab and field notebooks, appreciate professional ethics, and recognize that you can’t believe everything you read in technical journals.



We miss Gary and wish him all the best. His contributions to the Department and the geophysics community, and his impact on the minds and the lives of his students, will never be forgotten.

Among the innumerable anecdotes concerning Gary are these: –

* *In Hawaii all the students had to hike 1.5 miles over an active lava tube to reach our field site. It was about 90 degrees and humid. We were wearing long trousers, long-sleeved shirts, and gloves to protect us. We were all carrying gear (I carried the EM-31). It was a very difficult hike over the razor sharp lava flows. Just as we arrived at our site, Gary came flying in on a helicopter (due to his medical condition) wearing his big white cowboy hat, grinning with his little kid smile. It was great he could join us.*



* *“Detective Gary” helped the Golden police catch a robber. This unsuspecting individual made the unfortunate choice of trying to rob Gary’s house. Of course, Gary’s was no ordinary house. It was equipped with Gary’s custom state-of-the-art security camera system, including night vision capability. The robber forced open the garage door and tried to roll in under it, only to be stopped by a bigger version of Gary’s office – a mountain of boxes, books, and equipment all stacked to the roof. Dejected, the robber left and drove right by Gary’s cameras that captured the details of his vehicle.*

David Stillman, PhD 2006

* *One of my favorite Gary stories happened in Summer ‘98. Abraham Emond and I were doing a ground penetrating radar survey at Dinosaur Ridge. Our goal was to*

detect negative Iguanodontid tracks bulging out on the underside of the upper layer of Dakota sandstone. These slabs are pretty steep...maybe 50 degrees or more in places and quite high. High enough to need ropes. A rope for us, and a rope for the radar equipment. I think the orders were, ‘let Erin fall, save the GPR.’ Not really. Anyway we worked for several days doing radar lines every 20 cm across the entire slab, with Gary yelling up at us not to move so fast ‘cause any sudden moves would result in a loss of data’. Not an easy feat. Anyway, we needed the ropes set up at the top to secure us and hold the radar system...so every morning Gary would climb up the slab

(UNROPED) in his COWBOY BOOTS, set up the anchor and rope, then lower himself down! Remarkable. I still shake my head in disbelief.

Erin Wallin, PhD 2008

** I remember my first classes with Gary as a sophomore. He was really intimidating at first, and you could tell he was sharp. He could tell if anyone was talking about something they didn't actually know about, and would call them on it by staring at them until they talked themselves into a hole. He taught us it was okay if you didn't know things, as long as you admit it and go out and learn about it. Later on in the semester, he opened up to us with several great anecdotes about the scientific method or his research. The class and labs were hard; Gary expected a lot of us: keep good notes, design your own experiments, build them with your own hands, challenge yourself and others! But even though it was hard, it was very rewarding. I think we all learned a lot from him.*

One of my favorite labs from Gary was the mystery bag lab. He would fill a paper bag with an assortment of items (some easy, some hard), and we would have to figure out what was in the bag as an analog to figuring out what's inside the earth using geophysics. First, we weren't allowed to touch the bag, then we could gently disturb the bag (shaking, lifting), and then we could go to town and feel around the outside of the bag and isolate individual objects. Each time, we'd take a guess at what was inside, and why we thought so. At the end, we were allowed to see how close our guesses were, and inevitably we were totally wrong. It taught us to think critically about what we can/can't measure, how much we rely on our senses to understand the world, and why uncertainty and the effect of preconceptions in geophysics (and science in general) is an important subject. This was one of my favorite labs to TA as well.

Gary, thank you for sharing your knowledge and wisdom with all of us. You have taught us so many things that you can't just read from a textbook. Thank you for devoting so much time and effort into our learning. I am a better scientist because of you.

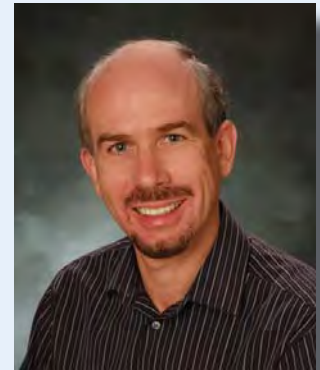
Alicia Hotovec, BS 2007, MS 2009



Congratulations...



...to Professor Roel Snieder on being named Honorary Member, SEG. Roel is also now Chair of Geophysicists Without Borders and was recently appointed Chief of the Genesee Fire Rescue Department in Golden.



...to Professor Ilya Tsvankin on being elected Fellow, Institute of Physics (IOP).

In Remembrance...

Geophysics Emeritus Professor and former Department Head, George Keller, passed away on April 24th in Evergreen, Colorado.

During his career, Dr. Keller was employed by the U.S. Geological Survey (1952-1963) as well as Colorado School of Mines (1960-1993).

At Mines, Dr. Keller's principal areas of interest were in the development and application of electrical geophysical methods to explore for mineral and energy resources. He served as head of the Department of Geophysics from 1974 to 1983. He retired from teaching in 1993.

A memorial service was held on May 12th at Mother Cabrini Shrine in Golden.

In Remembrance...

Philip Linwood Lawrence passed away July 9th. He was born in New Bedford, Massachusetts on March 27, 1923. Phil served in World War II in the 759th Field Artillery Battalion and graduated with a degree in Geological Engineering from the Colorado School of Mines in 1949. Phil worked for Mobil Oil as a geophysicist from 1949 until his retirement. After he retired, Phil was actively involved in many organizations; his favorites were Zane Grey's West Society and Numismatics International. Phil was a proud and devoted graduate of the Colorado School of Mines in Golden, Colorado and remained close to the school his entire life.



We are grateful to Phil for providing funding used to purchase new computers for our Linux lab. Our sincerest condolences go out to Phil's family.

Graduate Students Flock to Geophysics

Fall 2011 saw a new record for the largest number of new graduate students admitted to the Geophysics department - 24 - propelling the total number of Geophysics graduate students to 100. Some of their stories are profiled in the following pages and are as diverse as the places from which they hail.

Matthew Wisniewski, MS Student, Center for Rock Abuse

Graduating with a Bachelor of Science in Geophysical Engineering from the Colorado School of Mines has provided me some really cool opportunities. My first job after graduating was working for an airborne geophysics company. My time was mixed between working in our base office and travelling to work on an acquisition team. In the office I was involved in various aspects of the surveys including survey layout, data processing, and even interpretation. Field time was a mix of performing quality control of data and working with acquisition equipment; field work was exciting as new issues often arise and need to be handled promptly. On my last field assignment I was able to serve as crew chief which added the handling of survey logistics to my duties. My field assignments took me to Saudi Arabia and Greenland, places I otherwise would have probably never had the opportunity to see. Following this I moved to New Zealand where I worked with a small geophysical consulting company travelling throughout the country performing various surveys. It was a really great job assignment that involved a number of different geophysical techniques and varied applications. For example, we performed a refraction micro-tremor survey to characterize the area where a large storage building was to be placed. In another survey we used ground penetrating radar to look for buried structures from a historic Maori (people indigenous to New Zealand) settlement. I was also involved in a couple of gravity surveys aimed at characterizing the area around geothermal fields. In addition to multiple techniques, these jobs provided me the opportunity to work alongside people from various fields including pilots, airplane mechanics, technicians, geotechnical engineers, drillers, and others. I have returned to Colorado School of Mines because I am still excited about the field of geophysics and know that there is much more I still want to learn. With my work background I think I will be able to look at the presented material and understand it in a new way by relating it to my work experience. I am particularly interested in geothermal exploration as I think this will be an important application in the future, and I am hoping to perform research work and a thesis in this area. In addition, I am also excited to learn more about the many other areas of research happening in the department.



Kelsey Schiltz, MS Student, Reservoir Characterization Project

I'm just beginning my research which will focus on converted wave analysis of heavy oil sands at Nexen's Long Lake, Alberta. I'm originally from Montana but received my undergraduate degree from Rice University in Houston. Houston gets a bad rap; after four years, it has a special place in my heart. This is good because as a geophysicist in the oil and gas industry, I will most likely be spending a significant portion of my life there. I never planned on going into Geophysics, or science at all for that matter, but an introductory earth science class with a great professor sparked my interest in the topic. I gravitated toward Geophysics because I thought the ability of seismic to image the subsurface was awesome (and because I don't have much of an eye for geology). I chose Colorado School of Mines, and more specifically RCP, because of the group's reputation and direct ties with industry. I don't think I fully realized until I arrived, however, the extremely high caliber of the faculty and researchers here. Although I admit it is slightly intimidating, I feel so fortunate to have the opportunity to learn from some of the most brilliant and respected people in the field. Another huge draw for me was Colorado. I love the weather here, the small-town atmosphere with the proximity of a large city, and the active lifestyle. Since coming here, I have started trying new things like yoga, fishing, hiking, and in the winter, I'm looking forward to skiing. I am enjoying everything I am learning and looking forward to the next two years.



Jieyi Zhou, PhD Student, Hydrogeophysics and Porous Media

I am from Hunan Province, southeast of China, a very beautiful place. I studied acoustics as an undergraduate at Nanjing University, in one of the most glamorous cities in China. Acoustics is the physics of sound, and I like the concise and precise beauty of physics and mathematics. I have also been interested in geology since I was a child. The earth is so magical and appealing, like a kaleidoscope, attracting people to explore. I believe geophysics can lead to a better and deeper understanding of the earth. That is why I came to Mines, which has a great reputation in exploration geophysics. Though my exact research interest is yet to be decided, I hope I can understand what it is like under our feet and what is going on there. There are many things I love about Colorado, especially the mountains, the trees and the snow. I have tried hiking but not yet skiing. I am looking forward to it.



Anya Reitz, MS Student, Center for Gravity, Electrical and Magnetic Studies

I'm one of the less exciting in this fresh crop of graduate students; instead of garnering oodles of life experience between degrees, I opted to stay right where I was and further my education in a familiar environment. I received my undergraduate degree in Geophysics here at Mines in May 2011, and liked it so much the idea of staying on for another two years didn't faze me. Originally, I hail from Texas. As the daughter of two exploration geologists, it's extremely improbable that I'd never be exposed to Houston. Still, I've been in Golden, Colorado for three full years now, and I'd like to pretend I come from here. That's what my driver's license says, anyway. My research interests are very broad, though I tend to stick towards the non-seismic side of things in academia. I have been known to work on seismic projects during summer internships, including Cimarex Energy Co in downtown Denver in the summer of 2011. I am working for Apache in the summer of 2012. Currently, the focus of my master's thesis research is borehole gravity gradiometry and it's application in reservoir monitoring. I'd be lying if I said I didn't fall into the potential side of geophysics because of my fascination with colorful maps. I love my affiliation with CGEM.

I look forward to these next 2(?) years here in Golden. I hope they are just as great as the last three!



Esteban Diaz Pantin, MS Student, Center for Wave Phenomena

Since the time I was a geophysical engineering student at the Universidad Simón Bolívar I have known about CSM. It is very famous abroad because of Seismic Un*x. Also, I heard stories about CSM from my grandfather about his favorite brother who studied here in the early 1950's.



After obtaining my engineering degree I joined the seismic industry. I had the opportunity to work from 2D time data seismic processing to 3D depth imaging/model building projects. Later I had the chance to work in a research group with very talented and experienced people. After that I knew what I wanted to do in Geophysics. The decision to apply to Mines, and particularly to CWP, could not have been any easier. It was the research center with which I shared most of my interests. I am really happy working with people who have been pioneers in many aspects of seismic exploration. In CWP, I am on the I-Team, under the supervision of Dr.

Paul Sava. I plan to continue working in velocity model building. So far the experience has been great! Golden is a very nice town, and the people at CSM are very friendly. Looking back, I know I made the best choice!

Andrew Munoz, MS Student, Center for Wave Phenomena



I am a native Texan and graduated from Texas A&M University in the spring of 2010 with a B.S. in Geophysics. After I graduated, I entered into a long internship with Newfield Exploration, during which I learned about many oil and gas industry practices and problems. I applied to graduate schools all over the United States, but when I first visited Mines, I knew I was home. I met with all of the CWP professors and was warmly welcomed into the program. Dr. Dave Hale and I made a great connection, and held many similar interests in research and lifestyle; he was a natural pick for an advisor. As a Masters student, I would like to focus on improving the inefficient practices and inaccurate assumptions seismic interpreters use in oil and gas exploration. I hope to use my time at Mines to make a

relevant impact especially related to problems with well log and seismic data integration. Outside of school, I enjoy the many outdoor activities Colorado has to offer, and I have directed most of my free time to running, hiking and visiting parks.

Luiz Marcelo Ribeiro Martins, MS Student, Reservoir Characterization Project

I graduated in Geology in 1999 from the Universidade Federal de Ouro Preto (UFOP), in the State of Minas Gerais, Brazil. Two years later, I obtained a specialization degree in Petroleum Engineering at Universidade de Campinas (UNICAMP) in the State of São



Paulo. Between 2002 and 2004, I worked as a field manager for a drilling mining company in the countryside of the State of Minas Gerais. Since February 2004, I have been working as a geophysicist at Petrobras, mainly dealing with regional seismic interpretation.

At the beginning of my career at Petrobras, I took several internal courses that allowed me to have a better understanding of geophysics applied to petroleum exploration. In 2009 I attended the University of Houston, for a two month course on practical and theoretical aspects of Geophysics. In parallel, I have been working with the regional seismic interpretation team of Petrobras for the eastern Brazilian coast basins. My main

goal is to work in RCP, where I believe there is an appropriate environment to deal with multidisciplinary petroleum exploration technologies.

CSM has educated a number of geoscientists working for Petrobras. They all agree that CSM offers an intellectually stimulating environment for personal and technical growth. Moreover, Golden is a perfect place to live healthy and happy, and since I arrived here I've been so well treated. RCP students and staff are always helping and supporting me!



Seismic Hazard: Weakening of the Near Surface in Japan After the 2011 Tohoku-Oki Earthquake

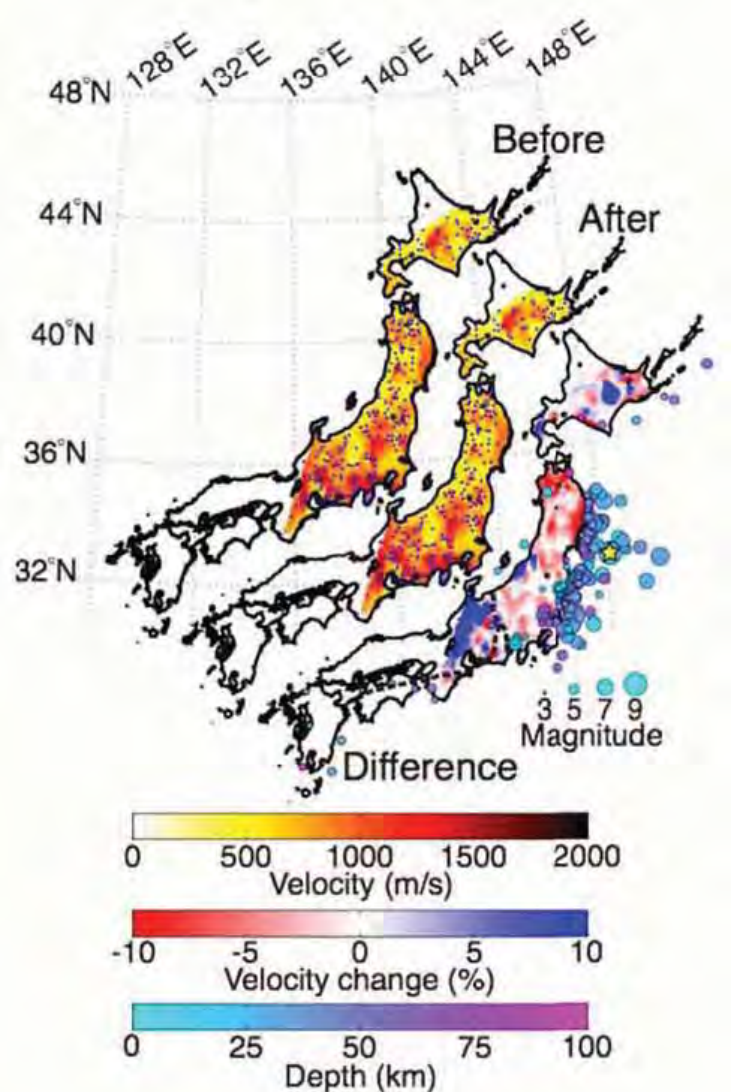
Nori Nakata, PhD Student & Professor Roel Snieder

The Tohoku-Oki earthquake (MW9.0) on 11 March 2011 is one of the largest earthquakes in recent times, and the resulting tsunami caused much damage in Japan including its nuclear reactors. This unprecedented earthquake has weakened the soil in the near surface throughout northeastern Japan.

We analyzed earthquake data from 1 January 2011 to 26 May 2011 recorded by KiK-net, the strong-motion network operated by NIED in Japan, to measure shear-wave velocities. Each station has two seismographs at the surface and the bottom of a borehole, a few hundred meters deep. By applying seismic interferometry to these two sensors, in which we deconvolve the seismogram at a top receiver with that at a bottom receiver, we retrieved the shear wave propagating from the bottom sensor to the top sensor at each station and thus determined the shear-wave velocity in the upper few hundred meters of the subsurface under each KiK-net station.

Using velocities of all available stations (blue dots on the maps), we create shear-wave velocity maps before (1 Jan. - 10 Mar. 2011) and after (12 Mar. - 26 May 2011) the Tohoku-Oki earthquake ("Before" and "After" maps in the figure). By subtracting the "Before" velocity from the "After" velocity, we obtain the map of the relative velocity change after the Tohoku-Oki earthquake ("Difference" in the figure).

As shown in the figure, the shear-wave velocity was reduced by about 5% after the Tohoku-Oki earthquake over an



Shear-wave velocities before and after the Tohoku-Oki earthquake and its difference.

area in northeastern Japan about 1,200 km wide. The shear-wave velocity is related to the shear modulus, which measures the strength of the soil; hence the reduction of the shear-wave velocity over northeastern Japan implies that the Tohoku-Oki earthquake reduced the shear strength of the near surface throughout northeastern Japan.

Seeing Earth's Hidden Secrets

Tongning Yang, PhD Candidate

One important goal in exploration geophysics is to discover natural resources, like oil, gas or other minerals. We achieve this goal by processing data acquired from various geophysical methods to interpretable images of the subsurface. These images are similar in character to the ones obtained in medical imaging and depend on the type of data used for analysis. For instance, with reflected seismic data we can obtain an image of the subsurface representing the geologic structures as contrasts of acoustic properties which are related to the lithology of the subsurface and to the fluids present in the rocks. This process is known as seismic imaging and is one of the most computationally intensive geophysical techniques.



One key element in seismic imaging is the velocity, or speed of seismic waves, in the subsurface. This information is necessary to relocate the reflections observed on the surface to their correct position in the subsurface. The accuracy of the subsurface seismic image is strongly dependent on this velocity reconstruction. The image is significantly improved and shows amazing details of the geologic structure, like layering and faulting which can guide oil and gas exploration.

My current research focuses on the technique known as wavefield tomography, one of the most advanced for velocity model building and one that receives a lot of attention in the geophysical community. A key demand of this methodology is to quickly simulate accurate seismic wavefields in complex geologic models, which is extremely computationally demanding. My research is facilitated by the High Performance Computing infrastructure provided by CSM through the Golden Energy Computing Organization (<http://geco.mines.edu>). CWP is one of the top users of computing resources on the available clusters. I am fortunate to have the opportunity to develop both my geophysical and computational skills and make an impact on such an important field.

“Seismology of Azimuthally Anisotropic Media and Seismic Fracture Characterization”

In their new book, **Professor Ilya Tsvankin and his colleague, Vladimir Grechka of Shell**, present a systematic analysis of seismic signatures for azimuthally anisotropic media and describes anisotropic inversion/ processing methods for wide-azimuth reflection data and VSP (vertical seismic profiling) surveys. The main focus is on kinematic parameter-estimation techniques operating with P-waves as well as with the combination of PP and PS (mode-converted) data. The part devoted to prestack amplitudes includes azimuthal AVO (amplitude variation with offset) analysis and a concise treatment of attenuation coefficients, which are highly sensitive to the presence of anisotropy. Discussion of fracture characterization is based on modern effective media theories and illustrates both the potential and limitations of seismic methods. Field-data examples highlight the improvements achieved by accounting for anisotropy in seismic processing, imaging, and fracture detection.



This book is published by the Society of Exploration Geophysicists (SEG) as part of the “Geophysical References Series” and is available as an eBook or in print edition from the SEG Digital Library at http://library.seg.org/ebooks/seg.geophysical_references_series/177e.

Reservoir Characterization Project



IN PURSUIT OF NEW IDEAS

“In Pursuit of New Ideas”

Ahmad Ihsan Ramdani

The History of RCP dates back to the mid-80’s. In 1985 Dr. Tom Davis formed the Reservoir Characterization Project (RCP), a research group in the Geophysics Department whose mission is to develop and apply multicomponent seismology and associated technologies to model and characterize complex reservoirs. Numerous field investigations, new concepts, new technologies, and multi-disciplinary integration are factors that have continuously evolved within RCP for more than 26 years. RCP’s Phase I research started with fractured reservoir characterization in Silo Field, Wyoming. In 2011, Phase XIV research included time-lapse multicomponent studies for CO₂ injection monitoring in Delhi Field, Louisiana; a heavy oil reservoir characterization study in Long Lake Field, Alberta, Canada; shale oil reservoir characterization in the Bakken Shale; and a shale gas reservoir characterization study in the Montney Shale, Canada.



Currently, 27 students are working in RCP and they come from different academic backgrounds and cultures. Most of the students are from the Geophysics Department, but there are students from the Geology and Petroleum Engineering departments as well. The students are distributed into different groups/teams based on their research interests. There are currently five active groups in RCP.

Delhi Team is the team that is working on time-lapse multicomponent for CO₂ injection monitoring in Delhi Field, Louisiana. This team works with one of the best time-lapse, multicomponent seismic data sets ever recorded by RCP. Currently, this team is focusing on delineating CO₂ migration flow paths controlled by the complex fluvial-deltaic setting of the reservoir.

Postle Team is working on time-lapse multicomponent monitoring of Water-Alternating-Gas (WAG) injection in Postle Field, Oklahoma. The reservoir interval is the Morrow A sandstone. This reservoir is below seismic resolution and seismic data were hypothesized to be impractical to map and monitor the reservoir. However, with the time-lapse multicomponent data acquired at Postle, RCP has been able to map the Morrow A sandstone and monitor the changes in the reservoir due to WAG injection.

In addition to the Enhanced Oil Recovery (EOR) Delhi and Postle Teams, RCP also has three Unconventional Reservoir Teams. The Pouce Coupe Team is working on reservoir characterization for Shale Gas in the Montney Shale, Pouce Coupe Field, Canada. The Bakken Team is working on reservoir characterization for Shale Oil in the Bakken Shale, Banner Field, North Dakota. Both of these teams are working on unconventional shale plays by conducting integrated geophysical, geological and geomechanical studies utilizing logs, cores, and thin sections with azimuthal anisotropic analysis from multicomponent seismic data. Our Heavy Oil Team is the team working on heavy oil characterization in Long Lake Field, Alberta, Canada. This team is working on the geomechanical effects of steam injection in the heavy oil reservoir.

November 10th and 11th, 2011 were two of the busiest days for RCP. All of the RCP students participated in a sponsors meeting. They made presentations and posters to show

their current research progress to the sponsors. In addition, the sponsors also gave presentations and made posters in which the interaction between students and sponsors was established. The students view their research as a part of their academic progress, while the sponsors view students' research as a "testing ground" for new technologies and new ideas and to see whether they are applicable or not. From this relationship, a good dialogue between sponsors and students is an essential component of RCP.

"In Pursuit of New Ideas" is the new RCP tagline and is reflected in our new logo. RCP aspires to create an environment that will spawn creativity and imagination. RCP will continue to be a worldwide entity that is recognized for creating value through innovative research and education. The technologies that RCP has been developing for the past 26 years are currently being applied in various parts of the world. And as the tagline says, RCP will keep pursuing new and innovative ideas.



Center for Gravity, Electrical and Magnetic Studies

GEM Beijing 2011: The SEG-CGS Workshop on Gravity, Electrical and Magnetic Methods and Their Applications



Xiong Li, Fugro Gravity & Magnetic Services & Yaoguo Li, Colorado School of Mines

GEM Beijing 2011, organized by SEG and CGS (the Chinese Geophysical Society), was held in the newly opened International Conference Center at China University of Geosciences (CUGB) in Beijing on 10–13 October 2011. The workshop was a great success thanks to

China implies a strong demand on natural resources. Rapid and massive construction in China also raises geotechnical and environmental challenges daily. Gravity, electrical, electromagnetic, and magnetic methods are effective tools for exploring

common technologies and methodologies. Sensors, acquisition techniques, and processing and interpretation methods are common. By bringing together this collection of applications, geophysicists can enjoy and learn from related applications of the same technology.

GEM Beijing 2011 International Workshop on Gravity, Electrical and Magnetic Methods and Their Applications



contributions of the two professional societies (Jian Guo of CGS in particular), local host (Xiaohong Meng in particular), authors, participants, sponsors, and many volunteers. Sustainable development in

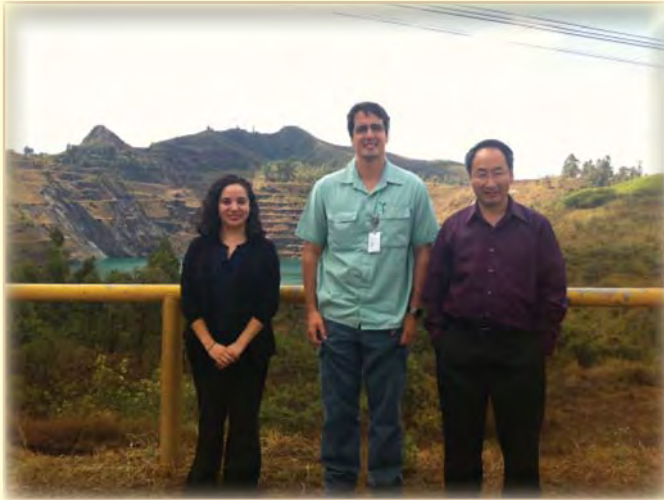
natural resources (oil and gas, minerals, geothermal energy) as well as tackling geotechnical and environmental problems. Although these different applications are diverse, they are all based on

CGS was the partner when SEG held its first conferences in China in the 1980s. SEG now has an international office in China and the two societies were delighted to work together again after *(continued on page 46)*

LEARNING OF LIFE AND GEOPHYSICS IN BRAZIL

Cericia Martinez and Jiajia Sun

Sandy beaches, sprawling forests, and a veritable cornucopia of geophysics. These are just a few of our favorite things...about Brazil! Whoever said 'all work and no play' was not familiar with the duties of a geophysicist. For us, our work and play were one and the same on a trip to Rio de Janeiro and the nearby state of Minas Gerais.



In August, we had the opportunity to attend and present at the 12th International Congress of the Brazilian Geophysical Society in Rio de Janeiro. While in the area, we visited the Quadrilátero Ferrífero, or Iron Quadrangle, which is an area of historic and significant mineral resources in Minas Gerais. During this two-pronged trip, we were able to sample the local culture and see some of the wondrous scenery and that served as a backdrop to our geophysical adventures. Drinking fresh coconut juice, watching the sunset from Sugar Loaf Mountain, and learning to samba were just a few of the perils we were obliged to enjoy. One of our fondest memories is Jiajia splashing against the tide in an attempt to

recover his sandal from the Atlantic Ocean. While that was a rookie mistake of walking along the beach with shoes on, it made for an excellent photographic sequence exhibiting how something can be 'just out of reach'. Needless to say, we both walked away with an appreciation of the deceptive calm ebb-and-flow of Copacabana's oceanfront. We also learned that Brazil is a hotspot for both breathtaking scenery and geophysics. In a weeklong conference, we were introduced to the many geophysical applications our Southern friends are faced with. We took note of the numerous geophysical applications and work being done to solve real world problems in Brazil. On a continent where mineral abundance is the norm and oil reserves have proven substantial, the utility of geophysics is in efficient characterization and production. The practical discussions we were able to have with our new Brazilian friends sent us home with multiple research areas to explore.

After Rio, we visited Minas Gerais for a tour of the mining region. Just as Colorado can be described by blue skies, the region around Belo Horizonte in Minas Gerais can be summed up with two words: red soil. It seemed like you could look in any direction and see evidence of iron formation simply by observing the color of the ground. We gained an understanding of the need for airborne geophysics while exploring the densely forested region. In traipsing around iron formation overrun with foliage, an army of Brazilian bees gave us practical experience in the hazards of ground geophysics.

Luckily, we walked away with only a few stings and did not encounter any slithering reptiles or other creatures that we were warned about. Altogether, we left Brazil with a deeper appreciation for applied geophysics problems, for Brazil's environmental beauty and dangers, and for the interweaved ramifications of doing geophysics in such a beautifully treacherous environment.





HYDROGEOPHYSICS AND POROUS MEDIA

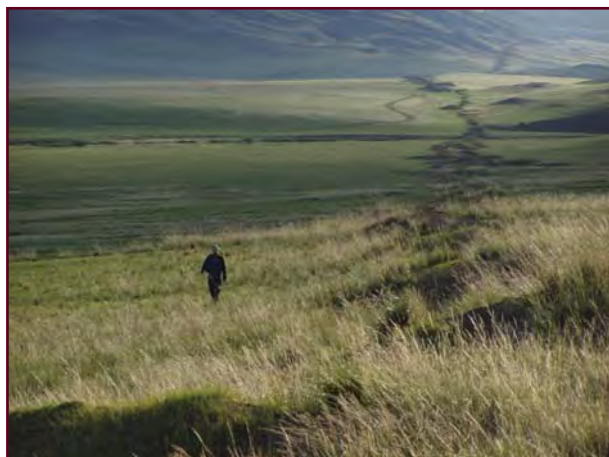
The second international workshop on induced polarization was organized at the Colorado School of Mines by André Revil from Monday, October 31 to November 3, 2011. Induced polarization is a non-intrusive geophysical method used to image the subsurface. Although historically developed to detect ore bodies, the induced polarization method has more recently emerged as an exciting technology in the field of hydrogeophysics and biogeophysics. In particular, literature over the last decade has conclusively demonstrated the unique potential of the induced polarization method as a geophysical imaging tool for characterizing hydraulic properties and monitoring biogeochemical transformations in the subsurface (e.g., for the remediation of contaminated soils). These recent developments have been in part driven by considerable improvements in the sensitivity of the instrumentation, macroscopic modeling and tomography techniques and the understanding of the microscopic origin of induced polarization

at the pore scale levels. However, there is still a gap in our fundamental understanding of induced polarization mechanisms and a unified theory is still missing. Consequently, the full potential of the induced polarization method as a non-invasive subsurface imaging tool has not been exploited. One fundamental problem is that various polarization mechanisms exist and may overlap in the frequency range of laboratory and field measurements. Sixty-one researchers from 16 nationalities registered for this workshop, which comprised 27 oral presentations and 19 posters organized in four sessions covering theory, laboratory and field measurements, tomography, and data interpretation. The last day included field testing of a time-domain induced polarization tool at Mines field by James LoCoco of Mount Sopris Instruments. This workshop was made possible thanks to the generous sponsorship of Tom LaFehr, the funding provided by DOE, and the organizational help provided by SPACE.

André Revil



Giant Earthquakes in Outer Mongolia



Mongolia is a land of extremes. Its northern reaches contain icy tundra, including the northern hemisphere's most southerly permafrost, while in the south, the fierce Gobi is Earth's most northerly desert. In between lies seemingly endless grassland interspersed with windswept mountains and pristine lakes. Mongolia's population of less than three million live in an area six times larger than Colorado, making it the most sparsely populated country in the world. Life for many of these people has changed little from the time of Genghis Khan, whose fearsome cavalry swept across Asia and into Europe 800 years ago, though thankfully Mongolians are a much friendlier bunch these days. For earthquake geologists like me, Mongolia

is known for other superlatives. In the early part of the Twentieth Century, it experienced a series of immense earthquakes, including the largest ever measured on Earth's continents. Continental earthquakes are rather different than those occurring in the oceans, being spread over wide regions rather than along narrow plate boundaries. Again, Mongolia is an extreme case: its fault-lines, and the mountain ranges that grow along them, are caused by collision between India and Tibet, 2000 miles to the south; Mongolia lies at the northern edge of what is the widest plate boundary zone in the world. My research here has focused on mapping the faults on which these powerful earthquakes occur, calculating how frequently these events occur, and determining how long the faults have been active. Fortunately, Mongolia's cold, semi-arid climate and its low population density mean that the landscape preserves clues about these questions. Much of the information can be obtained from the comfort of an office, using the latest high-resolution satellite images, but targeted fieldwork is still essential in order to collect rock samples for dating in the laboratory. This is also fortunate, as Mongolia is one of the most fascinating places that you could hope to visit.

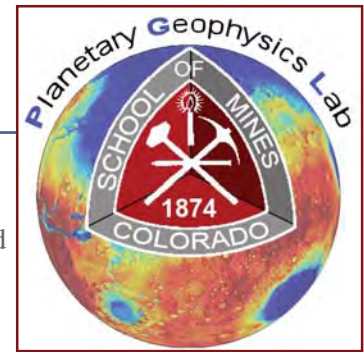
From top: Ruptures from the huge Bulnay earthquake of 1905 resembling a giant mole-track across the landscape; inquisitive locals; campsite



Dr. Edwin Nissen was recently hired by the Geophysics department to teach and conduct research in the area of earthquake seismology. His expertise is in Interferometric Synthetic Aperture Radar (InSAR), neotectonics, and geochronology. A graduate of the University of Oxford in 2008, he has held post-doctoral positions at the University of Cambridge and, most recently, the Arizona State University School of Earth and Space Exploration. He is using his expertise in imagery, geology and age dating to elucidate past movement on earthquake faults. Dr. Nissen was hired as part of the department's recent collaboration with the USGS to advance the study of geohazards.



Planetary Geophysics Lab



News and Notes from the Planetary Geophysics Lab

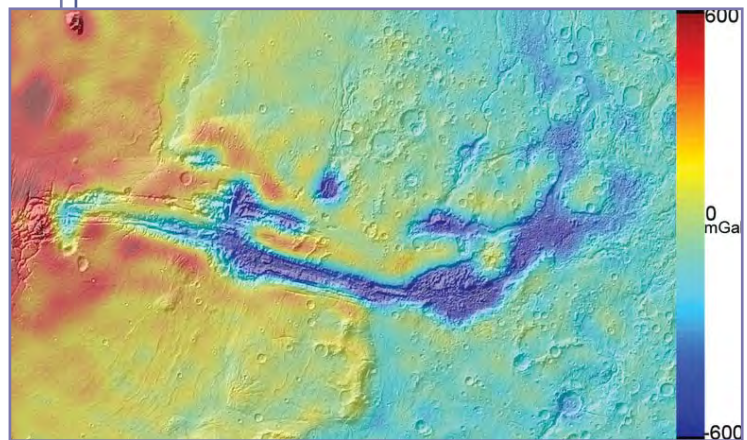
It's been a busy year for the Planetary Geophysics Lab. **Kelsey Zabrusky**, who began her thesis work in the Fall of 2009 after receiving her Bachelor's degree in geology from CSM, successfully defended



her Master's thesis in the Spring of 2011 and became the first student to graduate from the planetary geophysics lab. Her thesis focused on the controversial climate transition on Mars between the Noachian and Hesperian epochs when the climate shifted from warm and wet to cold and dry. Using a combination of spectroscopic and morphological analyses, Kelsey was able to better constrain the timing and length of this transition than had previously been determined. This research earned her the Dworknik award for the best student presentation at the 2011 Lunar and Planetary Science Conference. Kelsey will definitely be missed in the Planetary Geophysics Lab, but we wish her the best of luck in her future endeavors as a geological consultant with Gustavson Associates. The group also said goodbye to **Ryan**

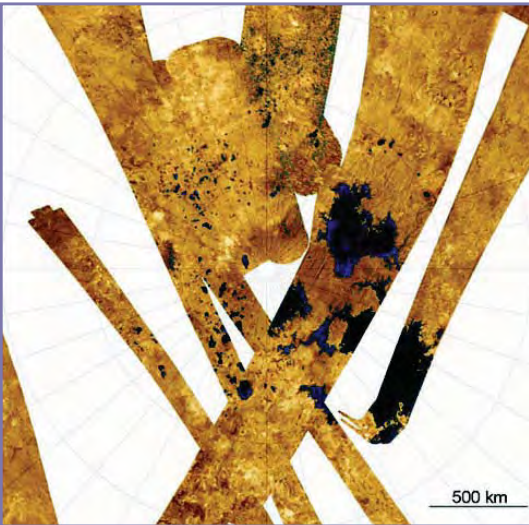
Isherwood, an undergraduate research assistant who graduated from the Geophysics Department in December. Ryan's research focused on Olympus Mons, the tallest volcano on Mars. His aim was to investigate how the topography around Olympus Mons changed as the planet deformed in response to the load of the volcano, and compare that to measures of the "paleo-topography". This is revealing new information about the history of this volcano and volcanism on Mars in general. He presented this work in a poster at the 2011 Lunar and Planetary Science Conference together with Lauren Jozwiak, a summer intern who worked with the group in 2010.

For the rest of us in the group, life goes on as usual as we continue working on our own research. **Brian Davis** continues to explore the geophysical implications of sedimentary erosion at Valles Marineris, the largest canyon system in the solar system. His work regarding the flexural response of the lithosphere due to this erosion



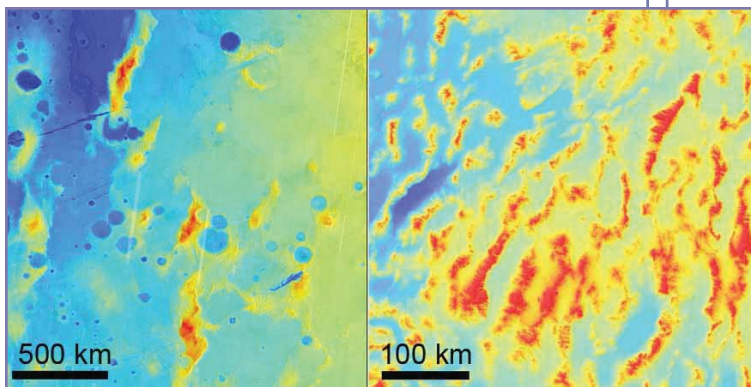
Gravity anomalies over Valles Marineris on Mars

earned him the first-place award at the CSM Graduate Student Research Fair, and he is now working to understand how this flexure affects the regional stresses in the lithosphere.



Lakes on Titan revealed by Cassini radar (Jaumann et al., 2009)

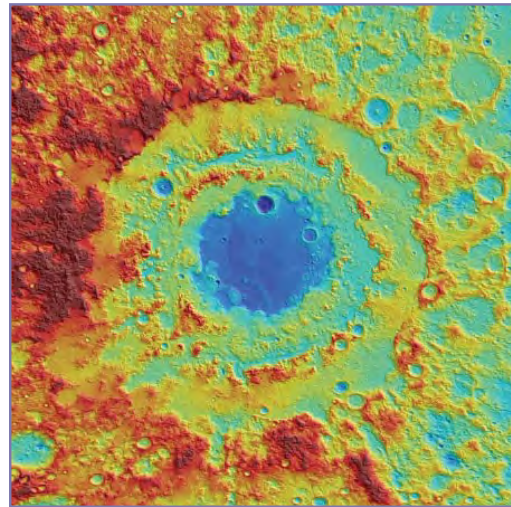
New to the group is **David Horvath** who began work on modeling the subsurface hydrological system on Titan. Similar to Earth, Titan is one of the few bodies in the Solar System where bodies of liquid are observed on the surface. Methane, which is usually in the gaseous state here on Earth, is in the form of a liquid on Titan and takes part in a hydrocarbon-based hydrological cycle. Meanwhile water on Titan is in the form of a solid due to the cold temperatures, and acts as the “bedrock” and “soil”. Although the liquids in the hydrological cycles of Earth and Titan are very different, observations have shown that they result in very similar systems of rivers, streams, and lakes. Like the Earth, flow of liquids beneath the surface is expected to play an important part in the hydrology of Titan. Dave is using



The topography of the south Tharsis ridge belt on Mars, and the basin and range province on Earth

the hydrological and atmospheric properties of Titan to model the subsurface flow and formation of lakes.

Ezgi Karasozen continues her research on understanding the formation mechanism of the South Tharsis Ridge Belt (STRB) on Mars. The STRB is among the oldest tectonic features associated with the huge volcanic province Tharsis. Therefore, it may provide key information on Tharsis’ early evolution and the ancient tectonic history of Mars. Previous studies interpreted these ridges as compressional features, but she has noted a striking resemblance between the South Tharsis Ridge Belt and the extensional Basin and



Topography of the Orientale impact basin on the Moon

Range province of the southwestern United States. She is evaluating both extensional and compressional hypotheses for the origin of the ridges using a variety of approaches. When the shape, size, spacing and symmetry of the ridges are considered, the Basin and Range province is the best analogue for the South Tharsis Ridge Belt, supporting an extensional origin. She will continue to study the formation of this unique ridge belt and its implications for early Mars.

Yaser Kattoum spends his time researching the internal structure of Orientale - the best-preserved multi-ring impact basin on the Moon. *(continued on page 47)*

An Alternative Earth

Warren Hamilton, Distinguished Senior Scientist

The popular geodynamic conjectures that whole-mantle circulation, including plumes from deep mantle, drives tectonic plates, and that plate tectonics has operated since early in Earth history, are extrapolated from 1960s geochemical speculations that Earth's fractionation is less than half finished: lower mantle is still mostly "primitive", upper mantle is slowly depleting, and continental crust is growing. **GP Distinguished Senior Scientist Warren Hamilton** is among the small minority that reaches diametrically opposite conclusions from geophysical, geologic, petrologic, mineral-physics, geochemical, isotopic, and solar-system data.

Main accretion was so rapid that Earth reached most of its final size by about 4.48 Ga. Early-accretion mechanism, including possible major heating by impacts and a Moon-forming mega-impact, is poorly constrained, but heating by short- and long-lived radioactive isotopes was probably alone adequate to account for accretion-concurrent differentiation into core, strongly depleted mantle, and thick global mafic protocrust. The extremely refractory uniform magnesian olivine that dominates cratonic upper mantle dates from this era. Less-refractory components of the global upper-mantle sample—rocks bearing pyroxene and garnet, and also water and CO₂—could

not have remained within that high-temperature residue or cumulate, and record progressive refertilization from the top throughout subsequent Earth history. The since-vanished mafic source for the voluminous tonalite and allied low-potassium granitic rocks that dominate preserved Archean crust, down to its base against extremely depleted mantle, was the protocrust, incremental melting of which began before 4.40 Ga. Densified residual protocrust delaminated, sank, bodily and metasomatically enriched upper mantle, and increased access of mantle heat to, and thereby recycling of, remaining protocrust and increasingly thick derivative overlying granitoids. Mafic and ultramafic Archean supracrustal rocks record melts from both protocrust and re-enriched mantle after ~3.7 Ga, and existence of a hydrosphere, as opposed to a hot and very dense supercritical atmosphere of H₂O and CO₂, is unproved before that time. Surviving Archean cratons owe their stabilization and preservation to loss of all subjacent protocrust, and hence the source of more tonalite, by 2.5 or 2.3 Ga, but protocrust-based processes continued elsewhere, with diminishing intensity, through early and middle Proterozoic time, when orogens were built mostly on pre-existing Archean granitic crust that, with voluminous clastic metasediments, was recycled into the potassic granites that typify those collapsing-geosyncline orogens.

There is no structural, geologic, or petrologic

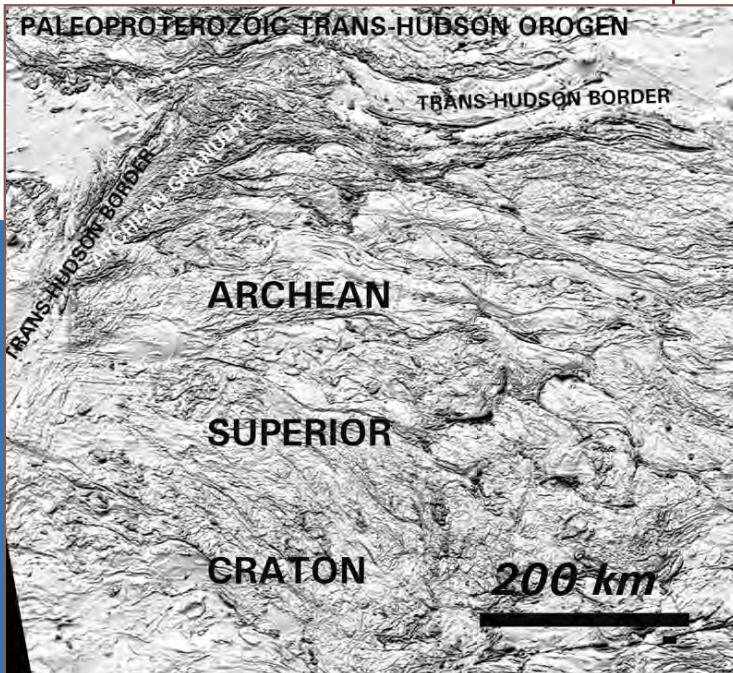


FIGURE 1. Archean upper-crustal development, which records response to long-continued lower-crustal mobility unlike anything in subsequent Earth history, is illustrated by this magnetic map of the northwest part of the Superior Craton, Manitoba and Ontario, Canada, as integrated with other geophysical and geologic data. Tonalitic lower crust rose slowly into overlying volcanic and sedimentary strata as large diapiric and remobilized batholiths, shown in least-modified form as the ~50x100 km ovoids in the southeast quarter of the map, between which the denser supracrustals sank. Simultaneously, the lower crust pervasively narrowed SSW-NNE and extended WNW, with a right-lateral component, smearing out the vertical-tectonic features in the variably decoupled and more brittle upper crust. The Archean crust of the craton margin was thinned extensionally early in Paleoproterozoic time, but continues beneath, and shows through, the Trans-Hudson orogen. Shaded-relief map of the crustal (high-frequency) component of total magnetic field, by Geological Survey of Canada.



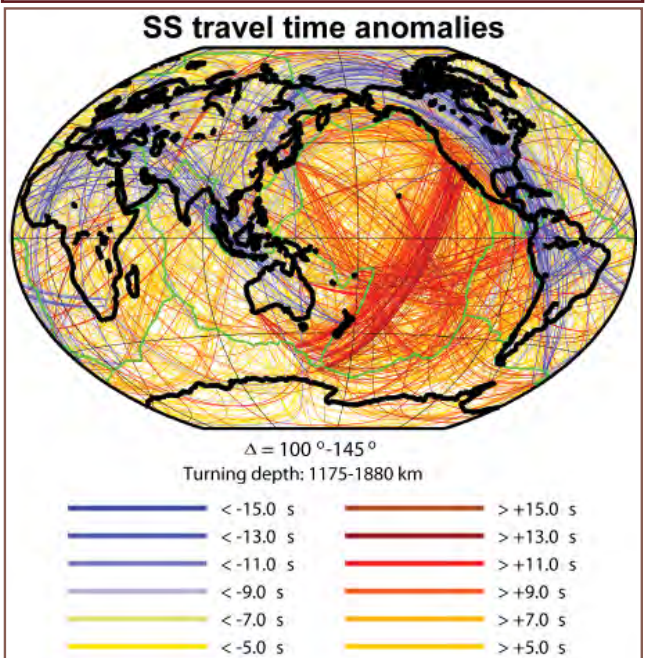
FIGURE 2. Polymetamorphic sheath-folded Archean basement, exposed by deep erosion through central part of Paleoproterozoic Limpopo Orogen, Limpopo River, South Africa. Zircon geochronology from this vicinity indicates crystallization of partial melts, from still older Archean crust, ~3.3 Ga, further plutonism and high-grade deformation ca. 2.6 Ga, deep burial by Proterozoic supracrustal rocks, and final plutonism and deformation ~2.0 Ga. Proterozoic supracrustals lap on to Archean cratons on both sides of the orogen, and other regions of Archean basement within the orogen are known. Photograph by Hamilton. Popular interpretations nevertheless assign both Limpopo and Trans-Hudson Proterozoic orogens to oceanic plate-tectonic processes.

evidence for either seafloor spreading or subduction before about 1.0 Ga, when a transitional regime began. Lithospheric oceans may have developed where there had been minimal generation of granitoids from protocrust. Popular assumptions of earlier Proterozoic and Archean plate tectonics are based on misapplications of ratios of trace elements in rocks strikingly unlike purported modern plate-related analogues both individually and in their petrologic, stratigraphic, and structural associations. Not until about 0.5 Ga was the upper mantle sufficiently re-enriched in low-melting and volatile components to enable fully-modern plate tectonics. Subduction continues downward fertilization and recycling of upper mantle with low-melting and volatile materials, enabling mobility and mantle magmatism despite planetary cooling as radioactivity wanes. Plate motions are self-organizing, and are driven by subduction that rights the density inversion produced by top-down cooling that forms oceanic lithosphere from asthenosphere.

All plate boundaries migrate. That plate circulation is confined to upper mantle, above the profound seismic discontinuity and thermodynamic phase barrier about 650 km deep, is shown by well-constrained seismic tomography. Penetration of the “650” purportedly illustrated by some tomography represents inappropriate modeling of non-constraining earthquake waves. Fluid-dynamic models purported to depict whole-mantle circulation combine irrelevant ideal Newtonian incompressible-liquid behavior with properties chosen, with disregard for mineral physics, because they enable desired pictorial results—and those results resemble nothing in actual plate kinematics. The possible extent of low-pressure syn-accretion depleting fractionation of what is now the lower mantle is unclear, but its sluggish circulation does not cross the “650”.

Warren’s latest published iteration of this four-dimensional contrarian model was in *Lithos* in 2011. Updates here have resulted in part from discussions of planetary formation with Anne Hofmeister and Robert Criss.

FIGURE 3. Seismic-tomographic depictions of purported slabs subducted below the 650-km discontinuity are artifacts of mis-assignment to the lower mantle of travel advances gained by subduction-zone earthquake waves that exit obliquely downward through anisotropic high-velocity slabs in the upper mantle. Representative evidence for this is provided by the 3-D geometry of recorded early-arriving SS raypaths, which at these teleseismic distances traverse the mid-lower mantle on each side of their Earth-surface reflection. Their time advances (blue lines) are not assigned properly to the source regions because of lack of recorded crossfire. Often-cited depictions of a slab deep beneath the Gulf of Mexico and southeastern United States, for example, represent mis-assignment of upper-mantle time advances gained in the Andean slab. Map by Jeroen Ritsema. Reliable tomography shows slabs to be laid down on the “650”. (Purported tomographic depictions of deep-mantle plumes represent arbitrary assignment to the lower mantle of relative slowness of through-the-core waves that rise steeply beneath some islands and are unconstrained by crossfire; the general method has been disavowed by its inventors, but its flawed products are still widely cited by plumologists. Reliable tomography shows “hotspots” to be confined to upper mantle.)



Colorado is Special Dave Hale, Professor

My wife Laura and I moved to Colorado from California in 1988. It took us an entire year to stop commenting on every interesting cloud we saw in a sky that seemed to us to *define* the color blue. Many years later, we are still discovering what a special place is home to the Colorado School of Mines.

Our son Kevin was born in Colorado. He grew up here. He rarely says anything at all about the clouds. It's just the sky. So when he graduated from high school last spring, and before he left for college, we decided to walk from Denver to Durango, a distance of about 485 miles on the Colorado Trail.



We left Denver on July 3 and arrived in Durango on the morning of July 27. Along the way we learned that somewhere between two and three miles per hour is truly the right pace to see and appreciate Colorado. We walked every day, although some days not far, as we were slowed down by large snowfields that remained after an unusually cool May and June. As for any trip of this sort, we hoped for enough challenges and lessons to make the experience memorable. We were not disappointed.

We used a GPS locator about twice per day so that Laura (mom) and Dawn Umpleby (think mom for *everyone* in Geophysics) would know where we were. When I returned

to Mines, I found the map Dawn used to track our progress pinned to my office door, with locations marked for every day we were on the trail. It's still there, reminding me that I must take another long walk.

Three to four weeks is a long time to unplug from the rest of the world, to not check email, to not work, to rarely see anyone except other hikers. I encourage Mines students to take that time, to appreciate Colorado and the years they spend here in some special way. Books and research and careers can wait a few weeks.

From top: Dave thinking about the clouds; We like snow in Colorado, but where is the trail?; Who wants to walk back to Denver? (We met someone who did.)



Date an Earth Scientist

Colton Kohnke, GP Sophomore

Based on "Date a Girl Who Reads" by Rosemarie Urquico in response to "You Should Date An Illiterate Girl" by Charles Warnke

Date an Earth Scientist. Date a girl who spends her money on gemstones not because they are pretty, but because she loves the intense underground processes which create them. Date a girl who has problems with closet space because of all the rocks she's collected on her travels. Date a girl who has a list of geological sites she wants to visit and tucks it in her hardhat.

Find her in the field. You'll be able to tell her apart because she'll be scribbling furiously in her field notebook and abusing rocks with her rock hammer. You'll see her licking the rocks to test the difference between NaCl and KCl. That's how you spot a geologist. They really can't resist licking a good rock.

She'll be the one at the coffee shop constantly refreshing the USGS earthquake website to see if any faults have ruptured while waiting for her order. If you overhear her order, it will have more caffeine than any human should consume in one sitting because she spent the last three nights modeling an interesting fault zone. Buy her another cup.

Talk to her about William Gilbert and geomagnetism. Let her know what you think of William Smith's accomplishments. Ask her to explain Alfred Wegner's ideas about plate tectonics. Let her describe Bowen's reaction series and paint the picture of formation conditions of her favorite rocks. Let her tell you of her dream to travel to Mars and experience first hand the processes of other planets. It's easy to date an Earth Scientist. Give her books on forensic geophysics, seafloor spreading, magnetism and remote sensing. Buy her new waterproof field notebooks, compasses, rock hammers, magnets and magnifying lenses. She'll keep the old ones because they have character, like the rocks, but she'll appreciate the gesture.

Let her know that you understand the rocks. That they speak to her and tell her stories of transgression and regression, of extinction and specialization. Always change like the rocks, they remain constant except over geologic time,

but to her that could be the blink of an eye. And always change for the better.

Fail her. Because an Earth Scientist knows that the world works in cycles. She'll know that you might just be going through a phase, that you can again become the man she loved. That life is meant to have a flood or two. The geology will be different when you two work it out, but it will be more fertile in the flood plain because of the flood.

If you find an Earth Scientist, keep her close. When she wakes up at 2 AM clutching her laptop and crying about a shallow magnitude 8.8 earthquake in Seattle, make her a cup of tea and comfort her. You might lose her to the volcanism, seismicity, and magnetic fields of the universe, but she will always come back to you. She'll talk as if the systems have personality, because for the moment, they do.

You'll propose to her in the middle of an earthquake. Or on top of an active volcano. Or during the launch of a new remote sensing satellite. Or casually on a hike to the summit of Mount St. Helens, on the anniversary of its eruption.

Together you two will have children with strange names such as Inge Lehmann, Mary Anning, and Li Shizhen. They'll have a taste for rocks, especially the mud-stones. You'll introduce them to geomagnetic reversals, banded iron formations and plate tectonics, perhaps all in the same day. You'll both cry when they decide to study Petroleum Engineering over Geophysics or Geological Engineering. You'll walk through your old age together, and she'll quote Steno's stratigraphic principles, because to her they are more romantic than any poem or sonnet.

Date an Earth Scientist because you deserve it. You deserve a girl that can take you around the world, under the surface of the Earth and to the farthest planets. If you only give her schist and granite, then you're better off alone because this girl deserves diamond. If you want the world and the worlds beyond it, date an Earth Scientist.

<http://www.delhi-university.co.in/blog/wp-content/uploads/2010/06/earth-science.gif>

One of the greatest things about Colorado School of Mines is the people.

Almost everyone here fits the recipe of fun, adventurous, daring, while maintaining the perfect splash of inner nerd! Just about every week a group of us goes out to do something out-of-the-ordinary. For example, we have watched the Moscow Nutcracker Ballet in Denver, enjoyed downtown Denver, went to a concert, watched a ski race and skied a bit ourselves, enjoyed a live-orchestrated rendition of the first (but silent) horror movie, swam in the local Creek in late October to prove we could handle the cold, hiked up a snowy mountain at sunset to enjoy the stars, attempted water-polo, attempted to ballroom dance and tango, epically failed a Halo tournament, gazed at the Parade of Lights, listened to a speech from Martin Luther King's speechwriter / confidante, and so much, much more! The classes are interesting and challenging, the area serene and inviting, but it is the people that are here that make me happy to call Mines home.

Elizabeth Pettinger, GP Sophomore





Why Geophysics?

The undergraduates on the following pages describe why they chose Geophysics as their major.

Explaining Geophysics

Stevie Newbill, GP Sophomore

Just before Christmas, I had the opportunity to sit down and talk to one of my close friend's five-year-old nephew. He asked me, "what are you going to be when you grow up?" I told him that I'm majoring in geophysics, and that I wasn't quite sure what I was going to do, but probably something with groundwater. This was the same response I had found myself giving time after time, to relatives, former teachers, even my own siblings. And then I remembered that I was talking to a 5-year-old, and that this rehearsed explanation was not something I had ever wanted to hear when I was five. I wanted to hear about people becoming fire fighters and astronauts, going off to join the circus, or becoming a professional football player. Not something called a 'geophysicist', going to work with water that we can't even see. So how do you explain to a kid why it is that this is exactly what you want to do now? How do you describe a fascination with magnetometers and seismic interpretation? Then suddenly I remembered a PowerPoint I had seen in class, one that compared medical imaging to geophysical imaging, and at that point I understood my subject better than ever before.

"I want to be an earth doctor," I told him. "ohhh," he said, "I didn't know that the earth needed doctors." So I explained to him about how the earth is always moving around, shedding off its crust like a skin in one place, while growing larger somewhere else. It is just layer after layer of one large being. I told him about how sometimes there are people who need to know what is happening inside the earth. People who need maps of what is under their feet that they cannot see. So, just like your doctors use big machines to see the inside of you, I will use mine to see the inside of our planet.

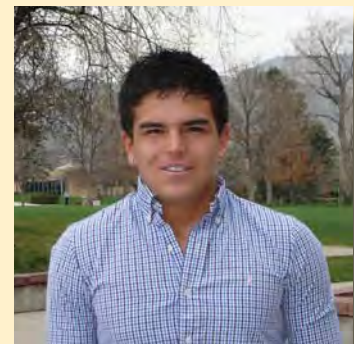


Life in the Geophysics Department

Gabe Martinez, GP Junior

Beginning in the sophomore year, geophysics students begin hammering out their major related courses. At a small engineering school, the Geophysics department continues with that same theme in being a small and tight unit. Unlike other majors, the Geophysics department offers one section of each major related course each semester. Because the department offers only one section of each class, geophysics students get to know their peers very well. Having the same students in each class of the day offers a unique college experience.

This experience can be felt in many different ways. With the same students in each class you form a bond with every person. The mood in most classes is typically very jubilant as the students have spent so much time together and have grown very close. The closeness is demonstrated very well in the learning process. Instead of having just the professor to clarify information, suddenly you have a classroom full of resources. In one class you may be asking a peer a question, and the next class period you may be answering a question to the same student. The closeness of the department is also demonstrated by the instructors who have a genuine interest in the success of their students and create an environment which fosters learning.



Why Geophysics?

Mohammed Almanaa, GP Junior

During high school years, I was interested in many different things that are totally unrelated to each other. I once wanted to be a veterinarian due to the fact that animals have been a big thing in my life ever since I was a kid. Then I was influenced by the TV series “Grey’s Anatomy,” so I wanted to be a surgeon. However, after a trip to a medical college with my high school, I clearly knew that I was not born to be a surgeon. When I was introduced to some geology courses in my junior year, I noticed that there was something about this field that strongly fascinated me.



Luckily, I was one of a few students who were accepted to a two-month program called SPS, Summer Program Special, at the Arabian American Oil Company. This opportunity enabled me to discover more about fields of study that are related to geology. We used to go to field trips to different places like inshore and offshore oil rigs and sometimes to places where oil rigs are remotely controlled and all the data that is received from the field is analyzed.

After finishing SPS, I researched the variety of majors that I had been introduced to, such as Petroleum Engineering, Geology, and Geophysics. I did not exactly know what I wanted to be until I read about all the majors and developed a clear idea of what it takes to be a successful professional in each one.

Among all of them, only one seemed almost perfectly suited for me. Besides my great interest in studying the earth, I have always been interested in physics. Physics was my second favorite subject after mathematics because of the way that it explains how things work. Therefore, Geophysics appeared to be the ideal major for a promising career. In addition, it is well known that the more a person loves what they do, the more they thrive. The fact that Geophysics is a combination of two of my favorite subjects makes me feel that I can be a successful professional in the long run. Moreover, one of the incentives that made me choose Geophysics over the other majors is that ARAMCO, my sponsoring company, is a petroleum-based company, so my major is highly valuable to them.

Leadership in Geophysics

David Huffington, GP Sophomore

All companies looking for candidates want someone with leadership qualities. They don’t need to look farther than any student in the geophysics department. For myself, I am currently a peer mentor for the school and the co-rush chair for Sigma Alpha Epsilon. But as I look around in my geophysics classes it seems that most of the students are in an executive position in their respective clubs. The students in geophysics all seem to be well balanced. Any employer could see the leadership traits that each student possesses.



Leadership does not just come from the students, but the professors are superb at showing the students what a leader looks like. It starts with the department head, Dr. Terry Young. He focuses on the students first and makes sure that they get a quality education. Dr. Young cares for all of the students along with the entire faculty in the department. Another person that I have gotten to know in these past couple of months is my advisor, Dr. Yaoguo Li. In our meeting regarding this semester he was able to take some time out of his hectic day to discuss what I was thinking about doing. He is genuinely interested in helping the students get the best experience possible in the undergraduate program. Overall the leadership from the faculty is emulated by the students which leads to a department that is boasting of top-tier students. Any potential employer need not look farther than at the Colorado School of Mines.

So Many Career Possibilities

Michael Dunham, GP Sophomore

I was born and raised on the Western slope of Colorado. Both of my parents were single parents for quite some time, so money has always been an issue. Growing up I learned that if I wanted something I had to work for it. I have been working since I was 14 .

Why did I choose Geophysics? For a majority of my time in high school, I actually wanted to do computer science. It was not until my junior year that I decided I like computers as a hobby, but I could not do it the rest of my life. So once I got admitted into CSM I started looking at majors. I had always been fond of earth sciences, and Geophysics caught my eye. I really love how Geophysics has so many different career possibilities – I can get one Bachelor’s Degree and have multiple career opportunities! I also find it very fascinating that geophysical methods can show what the subsurface “looks like” without being able to see it with the naked eye. Another aspect that grasped my admiration is how geophysical applications are used to locate geothermal energy. Renewable energy is something that I am very passionate about and I know that in the near future, renewable energies are sources the world is going to need to turn to.



Why did I choose Colorado School of Mines? My goal throughout high school was to become an engineer. I had done research and heard that CSM is a well-focused and prestigious school for engineering. I applied for early admission and a couple months later I found out that my application was denied because my ACT score was too low. I told my Calculus II teacher about it, and she called the school to ask them to reconsider. I got a letter two weeks later saying I was accepted. My cumulative GPA here at CSM is 3.94 with a 4.0 for the first year. This was unbelievable to me and came to show that test scores and numbers do not always represent potential. One thing is certain, if not for my Calculus teacher in high school, I certainly would not be writing this article right now. Thank you Anne Swanson, for giving me a chance for future success and opening a door to my dreams.

Advanced Engineering Math

Elena Dutcher, GP Sophomore

Until college, math was the only subject I ever enjoyed learning about. I wasn’t interested in writing, or chemistry, or foreign languages, and definitely not physical education. It made sense to me that at the Colorado School of Mines, the only fitting major would be a degree in applied mathematics. My first semester at Mines, I continued with this belief after taking NHV and Chemistry I and other introductory courses we are all required to take. Everything changed once I enrolled in the geophysics section of Advanced Engineering Mathematics.

After hearing about the mathematical applications to research in the field of geophysics, I was hooked. Advanced Engineering Mathematics introduced me to the applications of geophysics that had the same appeal as my classes devoted to only math, such as partial differential equations and linear algebra. After realizing



that I could use my passion for math combined with my interest in natural resources through

the geophysics department, I declared my major and have enjoyed every day since.

Being One of the Few

Liz Maag, GP Junior

Being a number or just a name on someone's list is not something I have ever been interested in. When looking into my future I knew I wanted to do something in Geophysics but the overall question was where to go for it? After a little research and a few college tours, CSM soon became my first choice. I wanted the small school atmosphere but I never realized how great it would be until I met my Geophysics class. There are just fewer than 30 of us juniors and no matter how different we all may be, we've formed this wonderful little group. Through our methods classes this past year we have learned to work together and it's amazing meeting people from all walks of life that have an interest in something many would say is very obscure.

When most of us have known each other for about 2 years and are able to sit in a room



together, study, laugh, and just be there for one another, you know you are part of something more than just a degree program. I had the opportunity to graduate early but when looking at the people around me and the opportunities outside of classes; I had no interest in trying to get ahead just for the sake of getting ahead. I wanted to be a part of something and the friends I have made here and the fun we have had has been well worth it. I can't imagine being one of the many at CSM who go through classes every semester in silence, not knowing even the person they are sitting next to. I feel very fortunate to be one of the few in classes where I know professors want me to succeed and where my classmates are here for me and I them.

Why Geophysics Rocks (and Occasionally Rolls)

Steven Plescia, GP Sophomore



Geophysics is a major that offers a multitude of careers that are both fun and challenging. Seismology is one discipline that especially rocks. Seismology studies earthquakes and the waves that travel through the earth. Earthquakes consist of four primary wave types: p-waves, s-waves, Raleigh waves and Love waves. Despite the names, these waves can provide shaking forces that can cause the land to sunder and buildings to collapse.

What I find most interesting about earthquakes though is that they are completely and utterly unpredictable. The only warning people in an earthquake have is the p-wave. P-waves arrive first and generally consist of a much weaker shaking force than the rest of the earthquake. P-waves however only give the unlucky victims a couple of seconds of warning at most. Beyond that, you are completely unprepared. Even foreshocks, smaller earthquakes that occur before the major quake, provide no reliable data as to when a massive earthquake will occur. Foreshocks and aftershocks only get their name from being chronologically before or after the main event. Foreshocks can reach magnitude seven or higher as long as the main event is larger like in the recent Japan earthquake. With no way to predict earthquakes, geophysicists are forced to study earthquakes and find ways to mitigate the damage.

Can you imagine dealing with a force that can level a city and come at any time? We do. Geophysicists constantly take on the biggest challenges facing the world today. Think you have what it takes to solve them?

Field Camp 2011 Meghan Helper, GP Senior

It is a tradition at the Colorado School of Mines to complete a field session at the end of a student's junior year. Last summer, the current seniors in geophysics followed in the footsteps of countless students before them, except that last year's field camp had a new and exciting twist. For many years, the geophysics field camp traveled to southern Colorado to explore and characterize the geothermal systems in Buena Vista, Poncha Springs, or Pagosa Springs. Last year's field camp, however, journeyed half way across the country, taking in the geology along the way, to Vale, Oregon. At Neal Hot Springs, US Geothermal is currently constructing a geothermal power plant. The first step in the students' adventure, was to pick up some friends from across the ocean: students from the Imperial College of London. Once the students reached Oregon, Boise Sate University geophysics students joined the CSM and ICL students. During the first two days the students acquainted themselves with the local geology. Over the next two weeks gravity, magnetics, electromagnetics, seismic, paleo-magnetics, electrical, self potential, GPS,



and magnetotelluric surveys were performed over and around the Neal Hot Spring surface expression. The days were filled with hard work but during the evening the students and teachers cut loose at the Sage Brush Saloon that graciously fed them during their stay in Oregon, or terrorized the bowling alley in Ontario, Oregon. But, alas, all good things must end, and the CSM and ICL students returned to Colorado to process the data. The students spent two more weeks processing, analyzing, and writing a report from the data collected in Oregon. The data correlated well between methods and offered a



comprehensive description of the geothermal system at Neal Hot Spring. At the end of the two weeks the students presented the results to faculty, staff, people from industry and the general public. The entire technical report can be found on the Department of Geophysics web page: <http://geophysics.mines.edu/GEO-Field-Camp> .



Study Abroad - Two Perspectives

One generally defines “study abroad” from their own perspective. The Geophysics department is fortunate to have American students travelling to other countries as well as students from other countries calling Mines their home away from home.

McBride Foreign Area Study 2011: South Africa

Patricia Littman, Chelsea Newgord, and Gordon Osterman

During the summer of 2011 we traveled to South Africa with eleven other students as part of the McBride Honors Program. The entire semester prior to the summer trip was spent studying and preparing for the experience that we would have in South Africa. Once we arrived, we had a whirlwind of cultural, scientific, and historical sites to see that all built on our knowledge from the past semester. We spent 24 days visiting locations ranging from township slums in Cape Town



and Johannesburg to prosperous diamond and platinum mines in the countryside. We visited the isolated and destitute country of Lesotho in the Drakensberg Mountains and the exquisite Kruger National Park. Each of these places provided a unique and memorable South African experience; however, we also spent time giving back to the South African community.

In the final leg of our journey, we stopped in a small village outside Kruger National Park for four days to build a playground for a small school

for mentally and physically disabled students. This school, named God’s Will Disabled School, has approximately thirty students with ages ranging from two to forty years old. The students are supported by the rural community and are taught by a volunteer principal named Levit. The playground was designed in conjunction with the EPICS program to provide both physical and mental stimulation to these students. With the help of EPICS students from the winning team we purchased all materials and completely built the playground in the allotted time. The playground now consists of a seesaw, swing set, music and shapes wall, talking tube, wagon, climbing ramp and fireman’s pole. We felt incredibly welcomed by the community and we hope that the school will benefit from the playground for many years to come.

Before leaving the village, Levit mentioned that the village lacked a consistent, direct water supply, instead requiring it to be trucked in from distant water sources. This not only creates economic hardships, but health hazards for the community. As geophysics students, we were in a unique position to help them. Since we got back, we have been working on a project in which we would return to the village with a suite of geophysical instruments to try and locate accessible groundwater for the community. So far this project has been very challenging from a logistical standpoint and has required collaboration with several professors, some from South Africa. Hopefully, completing this project will provide immense educational benefits to all the students involved, increase academic ties between Mines and universities abroad and most importantly, locate water for those in need.



Golden, Need I Say More?

Joan Jansen (JJ), GP/GE Exchange Student

When I started this adventure I didn't know what to expect. All my knowledge of America was based on the American movies I had seen. I found that, not unexpectedly, they do not represent the average American I have met. Americans are very nice and helpful. When I first arrived in Denver, they warned me that the blue shuttle would be way too expensive, so I should go by bus to Golden. I took their advice and went on my bus adventure. A guy that I asked for the right bus was very nice and managed to get me on the right bus. I did have to wait for about 45 minutes before the bus arrived, but at least it was free, because the machine wasn't working. Somewhere in Denver I had to transfer to another bus, and after riding that bus for about 5 minutes I had to transfer to another bus again. I still wasn't sure where I had to get off in Golden, so I asked the help of someone passing me on the street. Not only did he do his very best to find the exact stop, but he also gave me his bus ticket. Also, bus drivers were very willing and happy to help me, which I am not used to; in the Netherlands bus drivers are usually very cranky. Anyway, it took me about 4 hours to travel to Golden from the airport, but it was definitely cheaper than the blue shuttle, because it didn't cost me anything!



One of the things I love about Golden is the 'wildlife'. In the Netherlands we may see the occasional bunny, but no more than that. In Golden I have seen deer, badgers, squirrels, and even a lynx! That last one scared me a bit, especially because neither of us was aware of the other until I was only a meter away from him. We both jumped but the lynx recovered before I did, and looked at me with eyes that said: walk away now, or you're mine! So I thought it wise to slowly back away and leave him to his business.

While here I have met many amazing people, from all over the world. To me that is one of the best things about Mines.

Not only have I been able to experience the hospitality of the Americans, but Mines is a pleasant mix of all cultures, which are all appreciated and encouraged to be shared. That makes this a trip of many firsts to me. From the first time I ate Nerds, to the my first Thanksgiving, and the first time I had a job related to my study (thank you, Jeff!), or the first time I had Iranian food, or the first time I danced the Tango. Some things I loved better than others, but my mother always told me I had to try everything, and Golden offered a lot of opportunities to do just that.

One of my teachers once told me that diversity in someone's academic background is what makes someone a good scientist. I think Mines will do that for me. The system and way of teaching is so different here, that it has given me a different perspective on things I was so sure I knew before. I really have enjoyed my time here, it is an experience to never forget. I know it won't be the last Golden has seen of me as I am coming back to do a graduate study here (of course the many days of sunshine aren't exactly stopping me either.)!



CAVING IN IRELAND

Beth Behrens, GP Senior

Who knew Ireland had caves? I didn't. And who knew UCD (University College Dublin) would have a caving club? I didn't, but was very excited when this was discovered. Here's an example of a typical caving trip: Friday evening everybody heads to the shed to pick up their gear (undersuit, oversuit, wellies, helmet, light, belt, and possibly a wetsuit). After loading the very small cars with everyone's gear, everyone piles in. It's usually a two to four hour drive to the caving destination accommodations with a stop at a chipper (fast food restaurant) for supper. Everyone socializes until the wee morning hours, and a game of Twister might even be started up. It is eventually decided that sleep would be beneficial for the next day's adventures, and everyone heads to bed.

The next morning's wake up call might be some lovely heavy metal music or a very loud bell that was discovered along with the Christmas decorations (which were, of course, put up right after their discovery). After a traditional breakfast of cereal, toast, and tea it is decided which groups are going to which caves. If you're lucky enough to go to Pollnagollum, you'll have to wear a wetsuit because there are four underground lakes to swim through. If you're lucky enough to go to Shannon, you'll have to bring along the SRT (Single Rope Technique) gear because there is a 30m pitch to get down into the cave. If you're lucky enough to go to John Thomas you'll have a fun time cleaning your gear because you will literally be rolling around in mud in that cave. You may do two caves on Saturday if you wish, but either way you will be treated to the most delicious homecooked lasagna or spaghetti you've ever had. Caving really amps up the appetite. Saturday night usually involves more socializing than Friday and maybe some table traversing or leg wrestling or whatever other crazy competitions one comes up with.

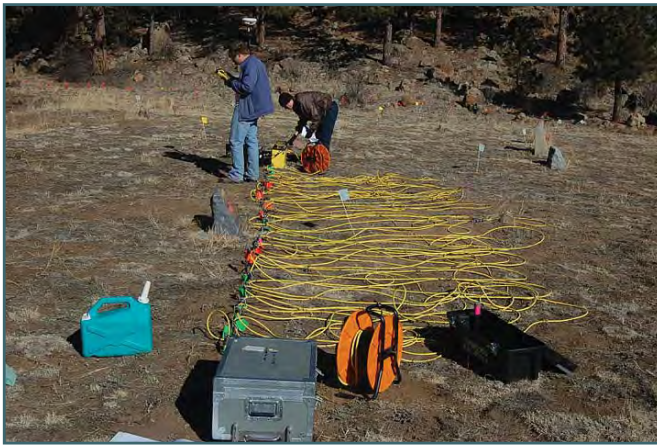
Sunday morning is much like Saturday morning, but a little more laid back. Unfortunately, you'll only get to do one cave on Sunday (unless you go cliff jumping instead) before heading home. Then comes the nice, relaxing car ride home where you're allowed some well deserved sleep.



Senior Design

Matthew Fackler, GP Senior

In the summer of 2011, Jim Plutt, an alumnus of CSM, contacted the Geophysics department requesting assistance with records of their cemetery. Lake George is a small town in Colorado and the graves in their cemetery were not all properly marked. By comparing an old map of the grave locations to the present day site, there were obviously some graves which had no apparent surface markings to represent their existence. For the purpose of having proper records, as well as to avoid putting new graves in the location of old ones, the grave locations needed to be known.



Geophysics was chosen as the best method to locate these graves since it would allow their discovery in a non-invasive manner. In the fall of 2011, Nicholas Kramer and I took on the project of finding these unmarked graves as a senior design project. We made several trips to the site for the purpose of data acquisition. The acquisition consisted of GPR, magnetics,

electromagnetics, and electrical resistivity surveys. By using multiple methods, we will be able to find correlations between the data sets, ultimately allowing us to confidently make interpretations as to the locations of the unmarked graves. We also spent a good deal of the fall processing our data, and we finished the processing and interpretation this spring. With this work complete, the location of the unmarked graves in the Lake George Cemetery will be precisely known. After the completion of our project, there will still be work to be done. Our survey covers only a portion of the cemetery, requiring future surveys of the site. In addition, there are other cemeteries to be surveyed near Lake George. This will likely provide a steady source of senior design projects for years to come.



Geophysics Students Experience Internships in Golden and Around the World

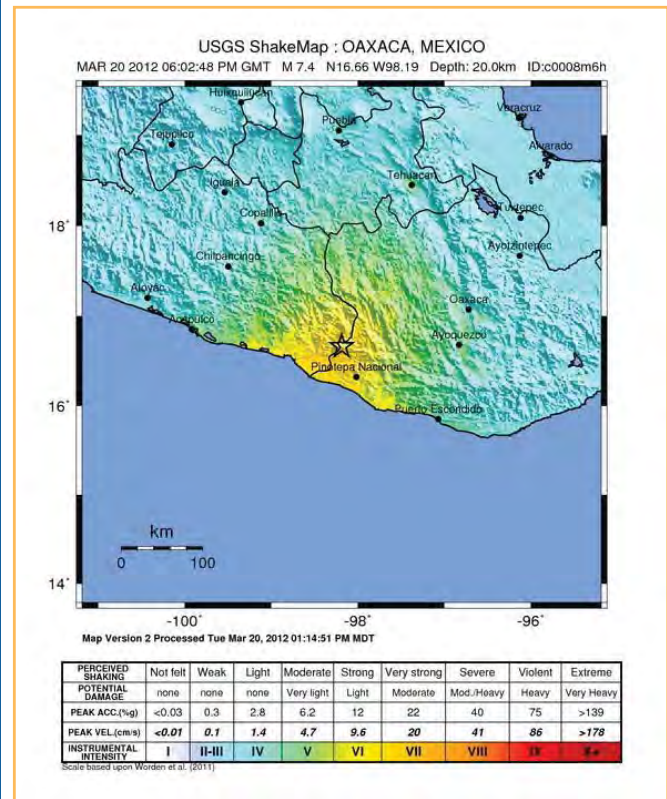
ShakeMap

Kendra Johnson, GP Senior

Since spring of 2011, I have been working for the U.S. Geological Survey (USGS) at the Geologic Hazards Science Center here in Golden, CO. My main role is to aid in completing the ShakeMap Atlas 2.0, which is a collective study of over 5,000 historical earthquakes all around the world which occurred since 1973, and are considered most damaging or most potentially damaging. The time I have spent at the USGS has taught me more than I ever expected about geophysics, including the topics of earthquakes, data processing, and studying science as a team.

Throughout my education at Colorado School of Mines, I have learned that everything about science is far more complicated than I initially expected; earthquake seismology is no exception. The number of parameters affecting the consequences of an earthquake seems infinite. My work on the Atlas has shown me that earthquake magnitude, the commonly understood system that rates an earthquake's energy release, does not always have as high an impact on human consequences as the tectonic environment, age of faulting surface geology, proximity to the epicenter, and preparedness for the relevant seismic hazard among other factors. I have also learned that earthquakes are an everyday occurrence, despite how only those that expose civilizations to intense shaking are widely publicized. Working with ShakeMap has helped me to grow a great appreciation for the art of computer science. While the computer science courses I have taken at Mines have included practical applications of programming to data processing, ShakeMap has highlighted the incredible

convenience and power possessed by a script. ShakeMap has the capability to take small files containing information about an earthquake, and sometimes data files describing the earthquake's behavior at geographical points, and produce maps that predict how the ground moved, and the intensity of the shaking perceived at the surface, all in a matter of minutes. What I find even more incredible



is that these maps are produced immediately following an earthquake, despite its location, with no human instruction, all based on signals from global seismometers. The advanced technology of today gives humans a much greater chance of understanding the natural world.

I constantly find myself impressed with the collective knowledge of the USGS, in particular the National Earthquake Information

Center (NEIC) and Prompt Assessment of Global Earthquakes for Response (PAGER) team, whom I observe directly, and who use ShakeMap products regularly. Everyone involved has a different background; there are seismologists, geophysicists, civil engineers, computer scientists, and more, and each makes an important contribution to the team. The team encompasses a variety of ethnicities and ages, and each member has a specialty that makes him or her important to the team. Often, only one person has even an inkling of an idea of the prominence of a theory, software, or otherwise, and the success of the team therefore relies on the combined specialties of everyone. This truth has been emphasized in many of my classes from middle school through Mines, but experiencing it first hand has caused me to really believe it.

My time at the USGS has inspired me to continue my education in the field of earthquake seismology. My involvement in ShakeMap has increased my curiosity in the dynamics of the Earth, and shown me how mature a science earthquake seismology is and yet how much room it has to grow. The opportunity I have to experience real-life workplace and research has been very beneficial to my attitude toward both school, and my future.

Shakemap image courtesy of USGS

Rollin' with Zonge Geophysics

Jake Utley, GP Sophomore

This last year I have been interning with Zonge Geophysics, a firm with a branch in Lakewood that has a reputation of being one of the few who don't dip their hands in petroleum. They pride themselves in being a part of the 10% who do everything else such as seismic, groundwater, and many other things. This summer I had the opportunity to jump on the train over in Lakewood and help them around the office and eventually in the field to improve myself as a geophysical engineer. My summer months were mainly spent in my own cubical editing reports and doing mapping. By the end of the summer I had become fairly acquainted with the Oasis and Surfer mapping programs after creating over 600 maps in Oasis, and editing nearly 50 in Surfer. This would be the equivalent of creating or editing the same number of parts in a Solid Works program as a mechanical engineer. I was very excited to have the opportunity to get ahead on programs that I could be potentially using in the



future maybe at the same firm or somewhere else. My job wasn't just sitting in a chair, I also helped one of their lead engineers modify many pieces of equipment that were used in the field week after week. I didn't necessarily have the technological background to improve its accuracy, but I would improve the ease of use in the field by either making it more comfortable, or reducing human interference. My work in the future, if I continue my employment, will mainly be field work; running and operating machines that I could also be modifying for efficiency. With football at CSM on my schedule as well, my time hasn't been so forgiving as to let me get back this fall, but I plan to stop in a few times this spring and possibly head back full-time this summer. Internships in your field of work are key to not only your working abilities, but also your confidence to do the job right in the future.

Not a Desk Job

Kyle Heser, GP Sophomore

When you ask most college students about their internship experiences, responses are usually along the lines of “I got to sit at a desk and sort paperwork and make coffee for a couple weeks, but it’ll look good on my resumé.” It’s not often you hear “I spent eight weeks in the Nevada desert for fourteen hours a day, six days a week.” This is exactly how I’ve spent half of each of my past two summers employed by Navarro-Intera, a company that performs environmental characterization and remediation services (ECRS) at the Nevada National Security Site. NNSS, located in Mercury, Nevada, was the location of 1,021 nuclear test detonations between 1951 and 1992. In 1992, a moratorium was signed with the U.S.S.R. ceasing all test detonations. From this time until the present, NNSS has been the site of many national security programs and environmental remediation efforts.

In summers 2010 and 2011, I worked as an intern with the geophysics remediation program, focusing on groundwater analysis. Through utilization of monitoring information within groundwater wells, the size of a particular reservoir could be determined, as well as the concentrations of any radioactive materials or heavy metals and the rate of water movement.

I also had similar experiences with ground surface sampling of soils bordering detonation sites; focusing primarily on determining contamination levels within the soil. With this information, the Department of Energy is attempting to facilitate environmental clean-up as preparation for a community on previously uninhabitable land. While significant progress has been made, and contamination levels are well below EPA standards in many areas, there is still a long way to go with this remediation. I hope to remain a part of this exciting and educational experience.



Our Internship at Schlumberger Cambridge Research (SCR) ***Filippo Brogginì & Clement Fleury, PhD Students, CWP***

On Monday, nobody wants to go to work. But at Schlumberger Cambridge Research the beginning of the week has a “better taste”. Employees know that they can start the week with an amazing crème brûlée, a French dessert prepared by the chef of SCR cafeteria! This is just one of the many things that made this internship a wonderful experience.

We spent the last summer at SCR as student interns in the Geophysics group. There, we worked on projects related to surface wave interferometry and reverse-time seismic imaging. At SCR there’s a great atmosphere that fosters interaction among all the employees. Everybody always has time to answer a question and there’s always a chance to exchange some words while sipping a coffee during a break. And Friday soccer was the best way to start the weekend!

SCR is located in the wonderful city of Cambridge, with its famous and well renowned university. In our spare time we visited the city and went on a punting trip over the river Cam. This was a great summer for us and we came back to Golden with new ideas and new friends.



From Caracas to Anchorage

Andrea Vega, MS Student, Reservoir Characterization Project

I come from Caracas, a very chaotic but beautiful tropical city; full of people, trees, birds, green mountains. Last summer I interned for BP Exploration Alaska. Anchorage is 50 degrees North of Caracas, and is full of bears and moose, lakes, glaciers, and earthquakes.

During my internship with BP I worked with seismic time-lapse data, logs, drilling and production data at Milne Point, an oil field adjacent to Prudhoe Bay. The project involved integration of multiple data for the evaluation of health, safety and environmental (HSE) risks. During the 3 month period of my project I had the chance to show what I've learned at CSM and in RCP. It turned out well as I was the winner of BP's technical contest (Techno Fest) as the best technical work among the interns. The day of my final presentation the room was crowded with people standing around trying to fit in. I felt very proud of myself and very grateful for the opportunity to be there. I saw the great value of the faculties and research groups in our geophysics department. I succeeded! Summer in Anchorage was an amazing experience: kayaking, hiking to glaciers, shooting, grilling salmon and halibut, watching the sunset at midnight and being awakened by earthquakes! I have accepted a full-time offer from BP and I'll be moving to Anchorage next August. I'm looking forward to seeing the Aurora Borealis in the winter.



Internship in D.C. with ENSCO GeoSig Division

Thomas Rapstine, GP Junior

Last summer I had the opportunity to work at ENSCO Inc. in Springfield, VA with the Advanced Projects Applications, GeoSig division. I had the privilege to work with amazing equipment while writing code for data acquisition and processing. Typically there was a certain wave signal propagating through the ground that had to be recorded and analyzed. The projects I assisted with were all geophysics related and exposed me to the “ups” and “downs” of waves, to say the least. During the internship I had to learn MATLAB and LabView on the fly for writing code for data acquisition and processing, but it was well worth the effort since I am using those skills in my classes this semester and will likely use them in the future. Also, in case you are as geographically challenged as I am, Springfield is basically the southwestern portion of Washington D.C., which allowed me to rummage around the nation's capital for the entire summer. D.C. ended up being the biggest city I have ever set foot in; there was always something to see or experience. Everything but the traffic was incredible. During the internship I had the opportunity to work with brilliant ENSCO engineers from multiple fields of interest and learned how a team of engineers can function together to accomplish a project. The experience, friends and contacts I gained this past summer are invaluable in my education and solidified my decision become a Geophysicist.



Internship with Cimarex Energy

***Ashley Fish, MS Student,
Center for Wave Phenomena***

Cimarex Energy is the definition of high-octane! Two years ago I began my journey with Cimarex Energy as an intern on the Geophysical Analysis Team in Denver. On the very first day of my internship, the VP of Exploration sat down with me and explained that my internship project was an integral part of the company decision-making process. He explained that the results of my project would, ideally, increase their confidence when drilling wells. This confidence, it turns out, could be the difference between a million dollar loss and multimillion dollar profit... I believe that day the bar was set high. The course of my internship was intellectually challenging, to say the least. But, I did not “go it alone”. Accompanied with the high-octane greeting the first day on the job, I was welcomed warmly and was presented with a mentor who would guide me through the eccentricities of geophysics and industry. One-on-one tutoring and instruction from my mentor and other team members helped me develop the necessary tools and science background to successfully take on the objectives of my internship.

Over the course of two years, I was presented opportunities to work with

different industry experts within Cimarex Energy. They taught me valuable skills ranging from the fields of petrophysical formation evaluation, computer programming and in-house software development, reservoir engineering, drilling, production, geologic interpretation, petroleum economics, social and environmental impacts of petroleum exploration and production, all the way to exploration and geophysical data acquisition and imaging. In fact, Cimarex provided the opportunity for the interns to learn about all these aspects of industry, not only in the office, but in the field. During the course of my internship, Cimarex sent me on two educational

field-trips. To my surprise, the corporate jet was our mode of transportation to and from the field-sites! I felt like a princess, flying in class! Once on site, Cimarex employees took us through the full spectrum from exploration to production. We rode vibroseis, explored a drilling rig, and learned about well pumps and production. During the conclusion of one of the field trips, the Chief Geophysicist decided to expose us interns to some of the local culture... The UFO

Museum! To my surprise, there was a display within the museum that used Geophysics as evidence that there was a UFO crash site in the area.

Beyond learning about industry practices and local cultures, Cimarex afforded me the opportunity to forge strong networks and new friendships. Another geophysical intern and CSM graduate student, Anya Reitz, and I participated in the Denver



Bike to Work Day. We wore our Cimarex bike jerseys with pride! Often times the “girls” would have a lunch date and go to the Tuesday Food Truck day in the Civic Center Park or Boba Tea on 16th Street Mall. A bunch of the Cimarex girls even joined together and ran in the Mud Run for breast cancer last fall.

Cimarex Energy is one of the most warm and welcoming companies I have ever encountered. From the first day I started working for Cimarex, my teammates, coworkers, mentors, and bosses have made me feel welcome and a part of the Cimarex family. The company's overall atmosphere is very conducive to a productive, healthy environment. The demand for high quality performance is great and the pressure to do your best work is always present. Cimarex is, without a doubt, a high-octane company. Working for Cimarex Energy has been an absolute pleasure and delightful experience!

My Experience in Geophysics

Travis Pitcher, GP Senior

I decided to come into the field of geophysics for a different reason than most. Growing up, I always aspired to be a journalist. I wanted the big corner office at the New York Times, and to someday be Editor-in-Chief of a large publication. The work, travel, and general lifestyle associated with such a job appealed to me in an exciting way. But when it came time for me to apply to different universities, the job market for an aspiring young writer was not what you could call promising. So, given my love of the outdoors, and an interest in physics, I chose to study geophysics on a whim. It seemed like more of an obscure field that not many people studied, and the job front looked fantastic! That is how I ended up at Mines.

Nearly four years later, I am very pleased with my decision to come to the Colorado School of Mines to study geophysics. Since I arrived at Mines, I have grown to love the quiet atmosphere of Golden, the relatively small size of our department,



and the resources that are available in the area. Immediately following my freshman year, I was hired by the United States Geological Survey as an Engineering Technician on the Advanced National Seismic System Backbone task. My job is to maintain the ~100 seismic stations in the network, which requires significant travel to very interesting locations. In the three years I have had this job, I have learned countless things about geophysics, policy, and life in general. I have traveled the country, been introduced to high-profile scientists, worked on many different tasks, and applied geophysics in different situations. But most importantly, I complemented my education with real-world experience.

My internship has been valuable in so many ways. The work is exciting, the people are fascinating, and the results produced at the end of the day are always extraordinary. The combination of work along with my schoolwork has provided me a very thorough, enriching education. I cannot think of anything I would rather be doing!

GEOPHYSICS GRADUATES

Spring 2011



Doctor of Philosophy (Geophysics)

Werner Michael Heigl pictured with

Dr. Max Peeters

Master of Science (Geophysics)

Ali H. Araji

Christopher Englesma

Rafael Pinto Ortiz

Professional Master (Petroleum Reservoir Systems)

Kihong Kwon

Meirzhan Mukushev

Michael Pollachek

Bachelor of Science (Geophysical Engineering)

Rashed Al Ghenaim

Abdulla Al-Kobaisi

Banks Beasley

Qamar Bu-Khamseen

Catherine Cox

Ashley Fish

Alex House

Brent Putman

Anya Reitz

Dustyn Sale



GEOPHYSICS GRADUATES

Fall 2011



Doctor of Philosophy (Geophysics)

Brianne Douthit Hamm (with Dr. Terry Young)

Doctor of Philosophy (Petroleum Engineering)

Ayyoub Heris (with Dr. Tom Davis)

Master of Science (Geophysics)

Julio Frigerio Alejandro Maldonado Pena

Fernando Martinez Nier Ribeiro

Sidra Shahid Jeff Shoffner

Nataly Zerpa

Professional Master (Petroleum Reservoir Sys.)

Sam McManus



Master of Science (Geology)

Kelsey Zabrusky

Master of Science (Hydrology)

Arianne Dean



Bachelor of Science (Geophysical Engineering)

Andrew Hill

Ryan Isherwood

Cameron Keese

Essau Worthy-Blackwell

a long hiatus. For these reasons, it was believed that a workshop in China jointly organized by SEG and CGS would be an important and timely event. This expectation was borne out.

The workshop attracted 250 delegates, including 70 from outside China, who represented 17 countries: Australia, Canada, China, Denmark, Ethiopia, France, Germany, India, Iran, Kuwait, Malaysia, Peru, Romania, Saudi Arabia, Spain, United Kingdom, and the United States. The delegates are employed by instrument manufacturers, universities, national geological surveys, oil and gas companies, mining companies, and service contractors. The workshop provided an excellent forum for geophysicists from China and overseas to interact and network.

The number of abstracts submitted greatly exceeded the initial expectation; 24 poster and 73 oral presentations were accepted. Two-thirds of the speakers in the oral sessions came from outside China. As a result, there were two concurrent sessions for both oral and poster presentations. We are particularly thankful to the members of the Technical Program Committee and other experts who reviewed and edited abstracts. Their unselfish and meticulous effort significantly improved many presentations. Topics that were addressed ranged from instrumentation, field surveys, data processing, numerical modeling, inversion and interpretation in gravity, electrical, electromagnetic and magnetic methods, to a variety of case histories. There were many impressive presentations. SEG kindly sponsored the presentation of two Honorary Lectures, “Integrating well log, seismic, and CSEM data for reservoir characterization” by Lucy MacGregor and “Building on 3D geological knowledge through gravity and magnetic modeling workflows at regional to local scales” by Richard Lane. Four invited presentations were given by experts well known in their areas: “Airborne electromagnetic

surveys: A quantitative tool for groundwater management” by Jared D. Abraham, James C. Cannia, and Burke J. Minsley of the U.S. Geological Survey; “How to get twice as much exploration value from aeromagnetic surveys” by David Isles and Leigh Rankin of Australia; “Joint multi-geophysical inversion: Effective model integration, challenges and directions for future research” by Max Meju of Petronas; and “The new development trends of the airborne geophysical technology in China” by Shengqing Xiong of China Geological Survey.

A highlight was the banquet night. Complementing the delicious food were many traditional Chinese performing arts: ethnic dance, folk music, Beijing opera, a magic show, Kung Fu tea, rolling lamps (acrobatics), Sichuan opera face-changing, and fire breathers. It was an evening of fun and relaxation in the midst of intense scientific and technological discourse.

The workshop also successfully engaged and involved local geophysics students through direct participation and volunteer work. In particular, ten members of the SEG Student Chapter at CUGB served as volunteers at the workshop. These student volunteers, wearing green shirts, provided much-needed logistical support in many different aspects during the workshop. While serving as volunteers, they also had ample opportunities to listen to technical presentations. Their contribution to the success of this workshop was extremely valuable and greatly appreciated.

*SEG's Digital Library recently launched the Global Meeting Abstracts catalog. GEM Beijing 2011 is one of the first SEG events in addition to the Annual Meeting to use this as a repository of the abstracts. Some PPT files or their PDF versions will also be available from the catalog. All available files of this workshop can be found under “Global Meeting Abstracts” at: <http://library.seg.org>. Photos from this workshop can be viewed on the workshop Web page hosted at Colorado School of Mines at: <http://geophysics.mines.edu/cgem/gem2011.html>. This article is reprinted from the January 2012 edition of *The Leading Edge* with permission from the SEG.*

AGU.....More than Just Geophysics

Patricia Littman, GP Senior

If you are unsure about what career path to choose after graduating from Mines with a geophysics degree, but you don't think you want to enter industry just yet, then the annual AGU Fall Meeting is the place for you to visit. Upon entering the enormous Moscone Center in downtown San Francisco, it is immediately apparent that geophysics is much more than what we could possibly learn in four years, and in fact, the possibilities are endless. There are hundreds of lectures and posters discussing every form that geophysics can take including bio-geoscience, glaciology, atmospheric science, space physics, and applications of geoscience to policy just to name a few of the fields that fellow geophysicists have gone into. If you have absolutely no idea what direction you would like to go after getting your degree from CSM, the AGU Fall Meeting is the best five days one could ask for to figure it out. Yes it may not be the typical conference that most CSM faculty and students from the Geophysics Department attend, however, there are countless Mines alums from both the Geophysics Department and beyond that attend every year. Furthermore, if it is decided early on the AGU is a conference that you want to visit, there are a variety of scholarships to help undergraduate students attend the conference for little or no cost. I had a fantastic time at this conference and would highly recommend that any student, regardless of your post graduation interests, consider attending it as well. There is so much that can be learned in just 5 days when thousands of geophysicists from all over the world congregate in one great City!



Planetary Geophysics Lab (continued from page 21)

At ~900 km in diameter, Orientale consists of three concentric rings encircling the center of the basin. Though several theories have attempted to explain the formation of the rings, this remains an unanswered question. One promising theory suggests that the outer ring formed through normal faulting, as material inside the ring slumped inwards towards the basin center. Yaser's research is testing this theory to see if the signatures of the normal faults can be identified through gravity gradiometry. Using 3D gravity forward models of the basin, his research has shown that gravity data from Orientale can best be matched by two normal faults. His research aims to constrain the geometry of these rings faults and the internal structure of the basin, and thus to provide important information on the formation of the rings around basins in general.

Jeff Andrews-Hanna continues his

research on a variety of topics. One project is aimed at investigating the large-scale geodynamic processes responsible for the formation of Valles Marineris on Mars. In other work, he is trying to understand the large gravity anomalies observed over impact basins on the Moon. At the same time, work continues aimed at understanding groundwater flow patterns on Mars, and the formation of the sedimentary deposits observed by both the current Opportunity rover and the upcoming Curiosity rover.

There is a lot of exciting research being done on in the lab on a variety of topics. The common thread running through all of our work is the goal of understanding the physical processes at work on the planets in our Solar System. On a fundamental level, planets are simple places... matter obeys the laws of physics and stuff happens. We work to understand the connection between what we see on the planets and the underlying processes responsible.

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Geophysicists: The Jacks of All Trades Jarred Epeheimer, GP Sophomore

When I was in high school, I had a math teacher who would joke with her students about the “purity” of various studies. For example, physics involves applications of mathematics, so that, in turn, makes chemistry less pure than physics. Obviously her point was to argue that mathematics is the purest field of study, since it is not derived from any other field. For some reason, this observation has stuck with me over the years, and I recently found myself gauging how pure different majors are. What should I conclude about Geophysics?

As all students and established geophysicists know, there is no one subject that we must be the most knowledgeable in. Rather, we must be proficient in many: geology, physics, mathematics, and computer sciences to name a few. While an individual’s level of expertise in each area varies depending on how they apply their geophysical engineering degree, this realization has led me to classify the modern geophysicist as a Jack or Jill of all trades. As the completed saying would imply, does this mean that geophysicists are the masters of no trade? I suppose that would depend on the individual, but it is an interesting thought to consider. Nevertheless, I would much rather think of myself as a Jack of all trades than an impure scientist.

