geophysics

Colorado School of Mines

Spring 2006

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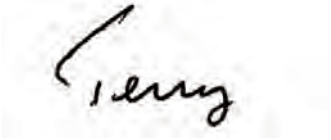
From the Department Head

Terry Young

In spite of the fact that our enrollment is perennially strong and growing, we are having trouble supplying the high recruitment demand for our students. It's a great time to be graduating with a degree in geophysics!

In this newsletter, as always, we introduce the activities of our Department by focusing on its people – students, faculty, staff, visitors. What a pleasure to welcome new faculty members Paul Sava and Feng (Suzie) Su this year, and to have Martin Landrø spend his sabbatical year with us. We have enjoyed watching our students thrive in their internships, study-abroad experiences, summer field camp, research activities, and extracurricular pursuits.

A bonus this year was the field venture in Hawaii, organized by our junior class to do geophysical measurements over active lava flow fields. Our international connections are as strong as ever, with both faculty and students circling the globe, and international students joining us from all over the world. I hope you have as much fun reading the articles about current hot topics, student life, research collaborations, and much more, as we have had in writing them for you!



On Our Cover

GP students Dustin Lanci and Kristen Schmidt pose during 2005 Field Camp in Chaffee County, Colorado. The story and more pictures are on page 3.

THE PROBLEM WITH WATER

Field Camp

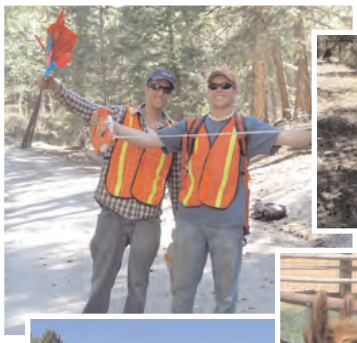
GOAL

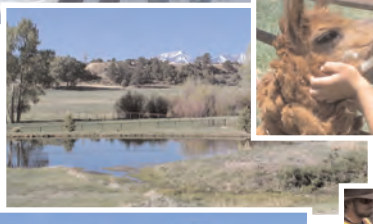
To provide students with field experience and to reinforce important concepts and practices learned in class.

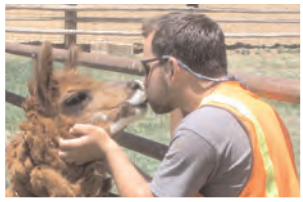
The 2005 Field Camp session, though located on a different site from past years, dealt with a familiar issue – water. This was a two-in-one experience for students as they divided their time on problems in two separate areas. One of the areas was near Salida, in Chaffee County Colorado in the Upper Arkansas Valley. Water availability is a critical issue in this area which relies on groundwater and whose population is expected to increase by 70% in the next 30 years.

The Field Camp students performed a deep seismic survey to accurately map the structure of the valley floor, the fault zones and the depth of the sediments filling the basin. This is the first such survey of the valley and the information will be vital to the county and municipalities as they plan for the future.

The second working site for Field Camp was on the High Trails Ranch at The Nature Place, just south of Florissant, Colorado. This area has suffered the effects of recent drought and wildfire activity. A recreational lake disappeared during the drought, and questions of groundwater movement and area wells arose. The CSM students performed surveys to characterize and quantify the regional subsurface and aquifer geometry.







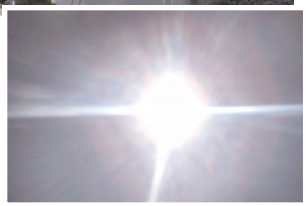
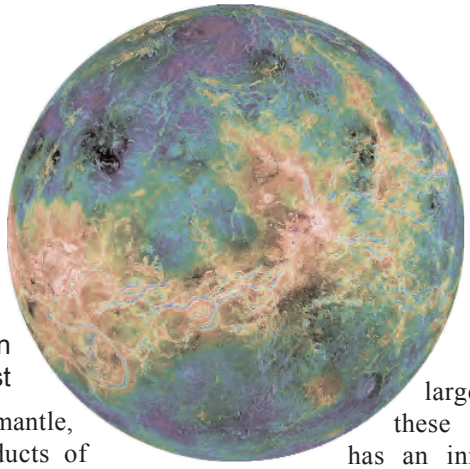


Plate Tectonics
Out of this World

– Warren Hamilton
Distinguished Senior Scientist



Warren Hamilton, Distinguished Senior Scientist, came to Mines after retiring from the USGS 10 years ago, and continues active research in geodynamics through time. He works with data across the spectrum of geology, geophysics, and geochemistry, and regards popular hypotheses of geodynamics as controverted by much empirical information.

Warren Hamilton

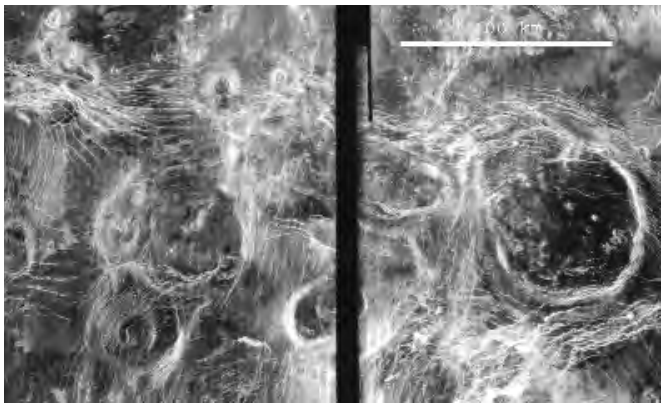
Where most see plate tectonics as driven by whole-mantle convection, Warren sees it as enabled by internal heat, but as driven by top-down cooling: the density inversion caused by chilling of asthenosphere to oceanic lithosphere is righted by subduction, which provides the primary drive for both subducting and overriding plates, and the 3-D circulation is limited to the upper mantle.

Where most assume plate tectonics to have operated throughout geological time, Warren sees products of plate-like processes (and those significantly different from modern ones) only in terrains younger than 2.1 billion years, earlier tectonics having been controlled by quite different heat-loss mechanisms.

Warren has expanded his studies to Venus, which is almost as large as Earth and which, all agree, lacks plate tectonics. Conventional explanations assume that Venus must lose as much heat as does Earth, and postulate that this hypothetical heat loss occurs as plumes, columns of hot material, rise from the base of the planet's mantle, and that the magmatic products of these plumes have wholly resurfaced Venus within the last billion or half-billion years. These plumes are assigned behaviors and products quite unlike those of hypothetical terrestrial plumes, which Warren regards as imaginary; and the overwhelmingly circular structures assumed to be products of the Venusian plumes are unlike anything known on Earth, or other objects in the Solar System, except for impact craters and basins.

Only a thousand small, unmodified craters and basins on Venus are widely accepted as of impact origin. (Most incoming bolides are destroyed in the atmosphere, which is almost 100 times denser than Earth's.)

The postulated products of Venusian plumes are the several thousand circular structures that saturate much of the planetary surface. (See figure.) Warren's evaluation of these old circular structures is that they are variably eroded and sediment-buried impact craters and basins; they commonly have rims steepest on the inside, broad outer ejecta blankets, and central peak and peak-ring uplifts, and many are multiring.



Synthetic-aperture radar image of Venusian surface saturated with circular structures conventionally attributed to young plume magmatism but interpreted by Warren Hamilton to be ancient impact craters and basins. Venus is shrouded in mist, and its surface is seen with satellite radar imagery. Area shown extends from 40 to 47 degrees North Latitude, and is centered on 222 degrees East Longitude. Mosaic provided by U.S. Geological Survey

The largest of these basins has an inner-rim diameter of 2000 km, and is one of the youngest of the structures that is older than the unmodified young craters.

Analogy with the Moon, whereon the last giant impact is well dated at 3.91 billion years, indicates the Venusian structures to be that old and older. Venus is almost as dead as the Moon and Mars, and much of its surface dates from end-stage main planetary accretion.

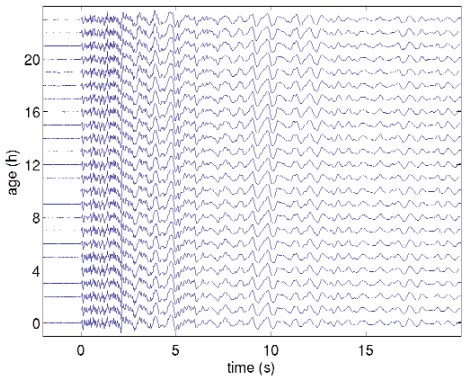
Warren's past contributions to geoscience have been honored with the Penrose Medal of the Geological Society of America, and with membership in the National Academy of Sciences. Time will tell whether he has more winning concepts.

Learning about Volcanoes

Monitoring Mt. St. Helens

– Roel Snieder, Professor

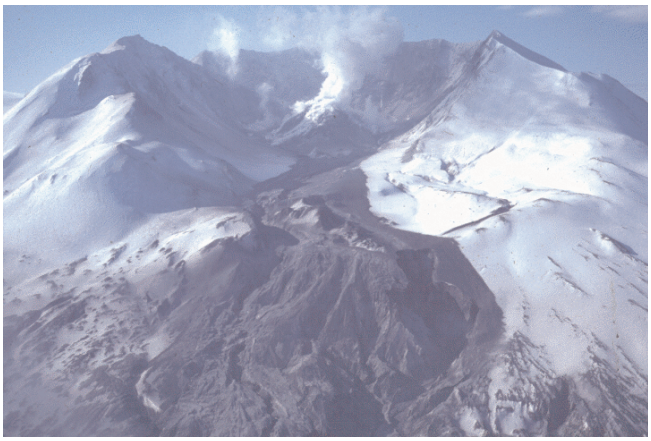
In 2004 Mount Saint Helens in Washington was active again. This volcano erupted violently in 1980 when part of the mountain was blown away. The activity in 2004 was accompanied by seismic events in the volcano.



The waves recorded on Mount Saint Helens that are generated by small earthquakes. These waveforms are shown at hourly intervals, indicated on the vertical axis.

Professor Roel Snieder is studying these seismic events in a collaborative project with Stephanie Prejean of the Alaska Volcano Observatory of the US Geological Survey.

The figure here shows seismic events recorded on Mount Saint Helens over a period of 24 hours. It is striking how repeatable these seismic events are. A closer analysis reveals that these waveforms slowly change over time.



Mt. St. Helen's erupting day.

Coda wave interferometry, developed by Snieder, is a technique to analyze minute changes in seismic waveforms. Snieder and Prejean showed that the changes in the waveforms can be explained by a movement of the source of these seismic events over a distance of about 100 m per

Senior Design Project Examines Kilauea

– Rich Krahenbuhl, Postdoctoral Fellow & Alicia Hotovec, GP Junior

In March 2006, a group of undergraduates and faculty traveled to Hawaii Volcanoes National Park to perform geophysical investigations on the world's most active volcano, Kilauea. The surveys were part of a Senior Design course required for all undergraduate students in the GP Department.

As part of the course requirements, a few select students took a leading role in identifying geophysical problems of interest to the National Park and USGS Hawaiian Volcano Observatory (HVO), chose appropriate geophysical methods for tackling these problems, designed and implemented the geophysical surveys, and processed and interpreted their data. The final product was presented to the faculty and members of the USGS Hawaiian Volcano Observatory as a final report/proposal, and as a formal presentation at Colorado School of Mines.

Littoral Cone on Kilauea in 1998 *– photo R. Krahenbuhl*

The students, while working as one large group for part of the study, also divided into two sub-groups for separate Senior Design projects and study on Kilauea. The first group tackled the problem of identifying subsurface structure associated with lava-tubes, caves, and old lava ponds beneath the current caldera floor. The second group helped to map active lava tubes throughout the active flow field to identify the hidden route(s) of lava transport from the active vent Pu`u `O`o to the Pacific Ocean.

The students will use their geophysical data to calculate lava-flux through tubes, thus predicting the amount of growth to the big island of Hawaii.

A Powerful force
Island Magnetism

– Todd Meglich, MS Student
Center for Gravity, Electrical & Magnetic Studies
(CGEM)


Todd Meglich

Unexploded Ordnance (UXO) contamination is one of the most dangerous environmental problems faced by the United States as well as over 80 other countries in the world. There is an estimated 11 million acres of UXO-contaminated land in the U.S. Since the mid 90's, geophysical methods including magnetics, electromagnetics, and ground penetrating radar have been used to help locate and identify buried ordnance items in clean-up efforts. The Geophysics Department at CSM is currently researching multiple projects involving the improved detection and discrimination of UXO. One project in particular involves the detection of UXO in magnetic environments. Magnetic soils may pose difficulties for both magnetic and electromagnetic methods, the two most common geophysical methods used for UXO detection. Soils with high magnetic susceptibilities may potentially mask the signal of buried UXO items in magnetic data. Current discrimination methods are not suited to recover the correct source parameters in these noisy environments. Electromagnetic methods may be negatively influenced by the presence of viscous remanent magnetization (VRM). Soils with VRM may exhibit multiple relaxation times when placed in an external time-varying magnetic field, such as that generated with electromagnetic induction instruments. Multiple relaxation times introduce unwanted noise in electromagnetic data and can mask the signal measured from buried UXO.

The soils around Golden happen to have very little or no magnetic material present. So, where could a poor graduate student convince his advisor to send him to obtain samples of magnetic soils? As it turns out, there isn't a better place than the Hawaiian Islands. Along with highly magnetic soils, several islands have UXO contamination problems dating back to World War II. With the help of the Hawaiian State Government and American Technologies, Inc., and in collaboration with the University of British Columbia, New Mexico Institute of Mining and Technology, Sky Research, Inc., and the US Army Corps of Engineers, we were able to collect geophysical data and soil samples from the Islands of Kaho'olawe (pronounced kah-ho-oh-lah-veh) and Hawaii. From 1941 to 1993, Kaho'olawe was used as a weapons testing area for ship and aircraft weapons. Full-scale UXO clearance operations began in 1997 and concluded in 2003. Helicopters were used to transport us and all of our gear to the island. Contrary to popular belief, we did work while on the island collecting electromagnetic and magnetic data as well as over 70 soil samples.


The camp on the western end of the island: the dining room on the left and the weight room on the right.

In addition to work performed on Kaho'olawe, we have collected geophysical data and over 150 soil samples from the Island of Hawaii and at Chevalier Ranch outside Helena, MT. Although the other trips proved to be both scientifically and visually interesting, the trip to Kaho'olawe is in a league of its own. It's not often you have an entire beach to yourself and have this type of view while eating dinner.


After a brief rain shower.

Heavy Oils:
A Worldwide Overview

– Amy Hinkle, MS Student &Mike Batzle, Professor

Amy Hinkle

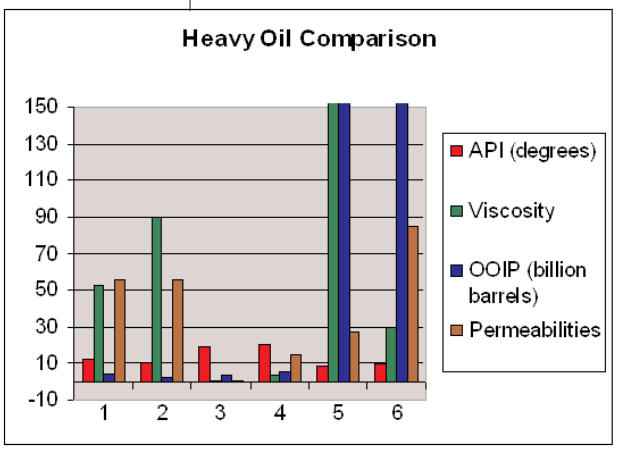
Heavy oil has recently become an important resource as conventional oil reservoirs have limited production and oil prices rise. More than 6 trillion barrels of oil in place have been attributed to the heaviest hydrocarbons. This is more than three times the amount of combined world reserves of conventional oil and gas. Of particular interest are the large heavy oil deposits of Canada and Venezuela, which together may account for about 55-65% of the known < 20 degree API (density > 0.93 g/cc) oil deposits in the world.

Heavy oils cover a large range of API gravities, from around 20 degrees for the lightest heavy oils to less than 10 degrees (> 1.0 g/cc) for extra heavy oils. This wide range of values means that heavy oils will vary greatly in their geophysical properties and extensive research will be required before these properties can be properly understood. There are several prevailing issues that are seen repeatedly in various fields around the world including measurements on unconsolidated sandstone cores, production of sand with oil and its effect on the formation, exsolution gas drive of heavy oil, and monitoring of steam recovery processes.

Heavy oils usually began as lighter oils (30 to 40 degrees API; = 0.876 to 0.825 g/cc) and are then altered, often by bio-degradation. With aerobic biodegradation, meteoric water supplies nutrients and oxygen and bacteria attack the lighter alkanes (straight chains) by oxidation, leaving the more complex compounds such as resins and asphaltenes behind. This is the most common mechanism for shallow heavy oils.

Heavy oil reservoirs are broadly distributed across the earth.

Oil sands can be quite complex, so pre-production reservoir description can be a primary goal of geophysical investigations. In recovery processes such as SAGD (steam assisted gravity drainage), sand continuity can be critical. The mobilized oil resulting from injected steam in an upper horizontal well must communicate with a lower producing well. However, in fluvial depositional environments typical of many of the oil sands, shale lenses and layers are common. Geophysical techniques must be able to differentiate zones of high shale content. Unfortunately, the difference in compressional velocities of the shales and sands may be very small, and may not allow them to be distinguished directly. AVO techniques show some promise in identifying lithologies.



A chart comparing heavy oil reservoirs from around the world: 1) Bakersfield, 2) Ugnu, AK, 3) West Sak, AK, 4) Duri Field, 5) Athabasca, and 6) Faja del Orincoco. (Note: The OOIP for Venezuela, and Canada, and the viscosity for Canada extend off of the chart.)

As alternative energy resources become increasingly important in the near future because of declining conventional reserves, it will be imperative to quantify the properties of heavy oil, one of the largest alternative fuels that remains largely unexplored.

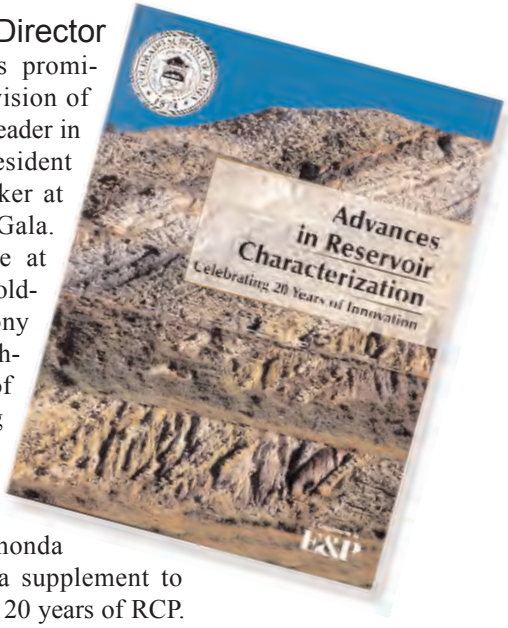
RESERVOIR CHARACTERIZATION PROJECT

Celebrating 20 Years

– Tom Davis, Director

The Reservoir Characterization Project (RCP) celebrated 20 years of progress during the Fall RCP Meeting 2005. Remarkably, RCP continues to flourish with strong support from approximately 25 industry and government sponsors. RCP operates in phases that are two years in duration and is currently wrapping up Phase X, a study of tight gas at Rulison Field, Colorado. Tight gas is the current "hot spot", especially in the Rockies, and RCP has been working on research to find "sweet spots" in on-going field development in Western Colorado through time-lapse multicomponent (9-C) seismology.

Approximately 70 students have obtained advanced degrees while working on RCP. Over 150 industry and government sponsors have brought 15 million dollars of funded research to Mines during this 20-year interval. In addition, at least 10 million dollars have been provided through in-kind services and participation. RCP continues to support students from geophysics, geology and petroleum engineering to work together on reservoir characterization research in an integrated team-oriented environment.



Energy research features prominently in the mission and vision of Mines and RCP has been a leader in this effort, according to President John Trefny, featured speaker at the RCP 20th Anniversary Gala. The celebration took place at Fossil Trace Golf Club in Golden, led by master of ceremony Sue Jackson from GX Technology, a division of Input/Output. Sue, along with Rhonda Duey from Hart Energy Publishing, carried the day with Sue organizing the gala and Rhonda producing and publishing a supplement to E&P magazine featuring the 20 years of RCP.

The event was filled with fellowship and goodwill, toasts and roasts. Commemorative beer steins, with the RCP logo, were provided as a memento. Mugs and hugs were the features of the evening, reflecting RCP's strongest asset – people.

Part of RCP's 2005-06 cast of characters: (front l to r) Michael O'Brien, Donald Walker, Lauri Burke, Liz LaBarre, Max Peeters; (middle row) Rodrigo Fuck, Tom Davis, Eldar Guliyev, Matt Casey, Bob Benson, Brent Riley, Shannon Higgins; (back row) Jim Emme, Gerardo Franco, Afolabi Babalola, Steve Hill, Michael Rumon, Marin Matesic and Donald Keighley.

The Path to GOLDEN

How do our students find their way to the study of geophysics and to the Colorado School of Mines? Two of our students describe their particular research interests

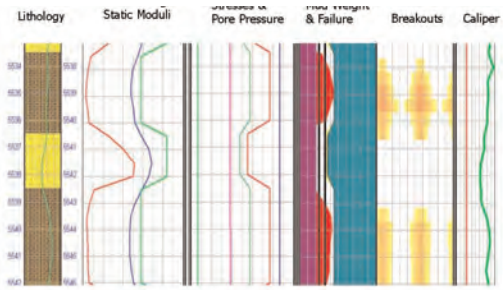
CSM Good Match for Geomechanics

Shannon Higgins, MS Student
Reservoir Characterization Project


Shannon Higgins

As an undergraduate at the University of Rochester I decided to seek a bachelor's degree in geomechanics. Yes, geomechanics was an actual degree program. In my graduating class there were three who earned this degree.

As a senior in college I had no idea what I was going to do, because no one



Example of a 1-D geomechanical model of a well at Rulison Field.

I knew had ever heard of this degree. Little did I know then, that in the oil and gas industry, geomechanics is one of the hottest industry buzz words. Today I find myself in the geophysics department at CSM pursuing a master's degree in geomechanics with a career already lined up in the same field.

Geomechanics has many definitions and applications. For simplicity, I like to think about it as understanding the stress in the earth and the role stress plays in all aspects of hydrocarbon recovery. Geomechanics is used to predict optimal mud weight during drilling, solve wellbore stability problems, prevent reservoir compaction, and help design better completions.

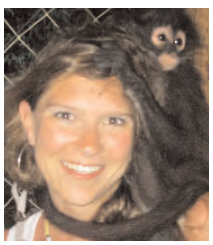
What does this mean in non-technical terms? The more we understand what's happening to stress underground, the better chance we have to find and produce more oil and gas.

I am working with the Reservoir Characterization Project (RCP) studying the integration of seismic properties and geomechanics. The RCP consortium has shot multi-component time-lapse seismic surveys over a tight gas sandstone field called Rulison Field, located near Rifle, Colorado. My challenge is to integrate this cutting edge seismic technology with the fairly new concept of geomechanics.

To accomplish this goal, I am building a one-dimensional geomechanical model for four wells in Rulison. For these four wells I am modeling stress and building empirical correlations to determine elastic moduli from well logs. With this modeling, I will be able to show how stress relates to elastic moduli and essentially sonic and seismic properties. In the end, I hope my research will show how geomechanics can be used to better characterize and understand an unconventional resource like tight gas.

Searching for Water on Mars

Brianne Douthit, GP Junior


Brianne Douthit

I have been interested in astronomy since I was very young and as I grew older I learned about the field of astrophysics, which greatly appealed to me. However, after meeting a few astrophysicists and looking further into the field, I decided it was too narrow for my taste. There were very few career options, and I didn't want to risk getting into a career that I didn't like.


The planet Mars

I learned that there are a number of geoscientists involved in space research. I looked into the field and I liked what I saw. I decided to pursue a career in geophysics.

When I came to CSM I began to search for a campus job. I didn't think any professor would want to hire a freshman who had been at the school for only two weeks, but department head Dr. Terry Young introduced me to Dr. Gary Olhoeft. After learning that I knew how to solder and had some experience as an auto mechanic, he hired me.

Since then I have worked on a NASA project researching the electrical and magnetic properties of Mars soil. The ultimate goal of this research is to help develop a ground penetrating radar (GPR) system to find subsurface water on Mars. I enjoy this work immensely because it fits so well with my interest in planetary science.

Many of the concepts and skills I have learned during the past three years have helped me in my classwork. Not only have I learned about GPR, but I have become better at working with tools and electronics. PhD student David Stillman and I launched a website about a year ago, and in the process I learned HTML and am maintaining my own website. Another positive aspect of my job is that I have been able to see what graduate research is like, and it has helped me decide that I want to attend graduate school. In short, I recommend undergraduate research work to anyone

USGS / CSM Partners – Learning by doing

Seismic in the Grand Tetons

– Jeff Fox, MS student

The summer before I began my graduate program at Mines I was fortunate to obtain an internship with the USGS at the National Earthquake Information Center (NEIC). Lucky for me the USGS was just starting up a new project and needed help. Thus began my adventures in Grand Teton National Park and the northern Rocky Mountains.

For the past two summers I was given the responsibility for the installation and maintenance of the Jackson Wyoming Regional Seismic Network. Only five days after beginning employment at the USGS I was headed to the field in Jackson Hole! I had a lot to learn and in very little time. That first summer we were to install the first four of nine seismic stations within Grand Teton National Park. I had to learn all about the Guralp broad-band seismometers, as well as the RefTek 130 data loggers and how all these electronic devices work together.

Checking data flow and the health of a station via a palm-pilot at station TPAW, up on Teton Pass.

Computer networking was also a big challenge. All of the stations, even though they are remotely located, have direct line-of-sight to broadcast their data to a receiver site that is connected to the internet. This is how the real-time data are transmitted back to Golden at NEIC.

Working in Jackson Hole is great! I had never been out west before moving to Colorado, and having the chance to work in such an amazing location has been exhilarating. Almost all of the stations are very remote, so it has given me a chance to see parts of the Tetons most people never see. Some of the stations are located on the west side of the range in Idaho and are very difficult to get to.

The work does not stop after the summer. I have had to visit some of the stations in winter for routine maintenance. That was my first introduction to snowmobiling, since it is the only way to get to the sites during that time of the year.

Due to the remoteness of these seismic stations, they are among the quietest in the country, with respect to background noise. I am also working on my master's thesis with the USGS and I am using data from these stations for calculating earthquake focal mechanisms. I am able to do moment tensor inversions for very low magnitude earthquakes in the intermountain west region with these data. It is comforting to know that the data I am using are coming from seismic stations that I installed myself.

Jeff Fox

The USGS has afforded me a great opportunity to do field work as well as analytical work in the lab using real time data. I have learned a great deal in the short amount of time that I have been here and it has complemented my graduate education immensely. I look forward to my continued employment with the USGS, as next summer I will be in the Caribbean doing field work as part of the tsunami warning project!

Learning to snowmobile is part of the job. Here Jeff is snowmobiling to seismic station REDW south of Grand Teton National Park.

Ground Penetrating Radar

– Justin Rittgers, GP Senior

This past summer three undergraduate students participated in a joint research project at the **USGS** located within the Denver Federal Center. Justin Rittgers, Alison Meininger and Trevor Irons had the unique opportunity to work with the Crustal Imaging and Characterization Team (CICT), developing a low-frequency ground penetrating radar (GPR) prototype.

At The Nature Place, (left to right) Trevor Irons, Chuck Oden, Alison Meininger.

This system was developed to improve the performance and applicability of GPR over lossy (conductive) media through the use of a low frequency signal and powerful electronics that allowed for real time digitizing of the data. According to Justin Rittgers , "The Federal Center in Denver offers the perfect location to test this system due to its naturally lossy soils and the presence of numerous known utility lines that function as good targets in GPR surveys."

Throughout the course of the project, the students' responsibilities included hardware fabrication, collecting and processing data, and seemingly endless system troubleshooting. Some of the highlights included the fabrication and deployment of a mobile radar flotation device (MRFD) ®, numerous local field tests, surveys during the 2005 CSM geophysics field session in the Rocky Mountains, and a glorious trip to the Idaho National Laboratory (INL).

In fulfillment of obligations to the DOE, partial supporters of the project, the MRFD was taken for testing to INL, in the heart of the Idaho badlands. There, the group spent 11 days conducting surveys at various sites, including a geophysical test cell and two of the US's first-running nuclear reactors.

This trip demonstrated how difficult it can be to keep such a prototype system running properly in variable field conditions. Trevor Irons notes "I got a good appreciation for how much R&D would be required to bring an idea into a fully functional and commercially viable product."

Justin Rittgers

Overall, the internship proved to be a good experience for the three undergraduates who were exposed to a talented USGS research group, and had a lot of fun, while making many friends.

Did You Feel It? Earthquake Mapping Project

– Tanya Slota, GP Senior

Tanya Slota

Through a classmate, Matt Donnelly, I was recommended for a project that GP adjunct professor David Wald was working on at the **USGS** in Golden. This Earthquake Hazards Program project is called "Did You Feel It?"

"Did you Feel it?" is a rapid community internet earthquake intensity mapping system to collect information about ground shaking following significant earthquakes.

From this web site, it is possible to report earthquakes you may feel yourself, or to find information about other reported incidents. Since beginning work, I have developed the relational database and interface, and have expanded this system from what was originally a collection restricted to the United States into a worldwide resource. Check out the web site for yourself (http://pasadena.wr.usgs.gov/shake/).

San Francisco Earthquake, 1906

USGS / CSM Learning Together

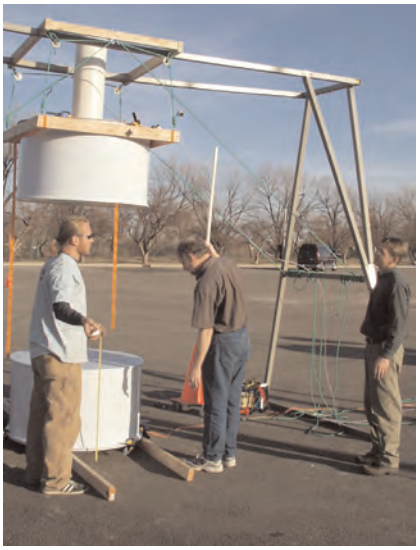
Project: Building and Calibrating a GPR System

– Chuck Oden, PhD Student

Chuck Oden

In a collaborative effort between the USGS and CSM, a prototype ground penetrating radar (GPR) system was designed and built.

This radar system, the real time digitizing GPR (RTDGPR), is designed for use in lossy or conductive ground. Conductive ground is a major problem with GPR because it limits penetration and reduces image resolution.



Bill, Craig Moulton (USGS), and Chuck conducting a calibration experiment at the Denver Federal Center.

The principal investigators were Dr. David Wright and Dr. Michael Powers of the USGS, and Dr. Gary Olhoeft at CSM. A number of students played a major role in the project. The project was the basis for Chuck Oden's PhD work. Graduate student Bill Woodruff and undergraduates Justin Rittgers, Trevor Irons, and Alison Meininger were invaluable assets in building, calibrating and testing the RTDGPR.

The RTDGPR is unique because it has a large dynamic range for better penetration in lossy soils, and because a major effort was spent calibrating the system. The response of radar systems using ground coupled antennas changes as a function of the soil properties under the antennas. This means that the response changes as the antennas move across the ground. With the RTDGPR, we are able to estimate the electrical properties of the soil beneath the antennas, and calculate the response of the antennas. This enables data processing techniques to make higher resolution images and better estimate the properties of buried objects.

Justin at the INL site– now this is four wheelin'.

These pictures describe some of the finer moments of the project. Although most of the calibration work was done at the USGS offices at the Denver Federal Center, we also spent a few days at Big Soda Lake in Lakewood, CO. There's nothing like doing geophysics in a beautiful setting. We made two major field outings with the RTDGPR. The first was at the CSM geophysics field camp at Sanborn Ranch, Colorado. The second was at the Idaho National Laboratories near Idaho Falls, ID.

This GPR project taught me how difficult it is to design a field-worthy geophysical instrument that produces quality results in many different field situations. Many of the geophysical instruments that we routinely use truly are technical marvels.

A calibration experiment. A day in the life of a GPR system – just relaxing at the beach.

Working on site at the Idaho National Laboratories.

– photos courtesy of the USGS

Heriot Watt Institute of Petroleum Engineering

Geophysics on Tour

Our students often have opportunities to travel abroad for exchange programs, collaborative projects or even just for fun! Sometimes all of these things are rolled into one experience.

Seeking Common Ground in Time Lapse Collaboration

– Matthew Casey, MS Student
Reservoir Characterization Project (RCP)

When I first arrived at CSM I knew little of what was in store for me besides that I was to do research with the Reservoir Characterization Project (RCP). Just two months into the semester of heavy course work my advisor, Tom Davis, suggested that I travel to Edinburgh, Scotland, to visit Heriot Watt Institute of Petroleum Engineering.

While there I visited with Dr. Colin Macbeth and Dr. Karl Stevens to discuss collaborating on mutual research objectives of coupling time-lapse seismic anomalies to geomechanical reservoir simulations. Their research group, the Edinburgh Time-lapse Project (ETLP), is roughly the same size as RCP (12-15 students). They focus their research on local regional problems such as North Sea reservoirs, much as RCP does research on tight gas sands in the Rocky Mountains.

I was able to meet with all of the ETLP students, post-docs and faculty and discuss their respective research projects and objectives It is very instructive to see how others think and approach similar problems, lending insight into one's own methods of research and problem solving.

This research objective is a daunting one that involves bringing together aspects of wave propagation, multiphase fluid flow in porous media, and the dark art of rock physics! Thus, it must a collaborative effort between the people who pursue it. Initially, it may involve solving reservoir specific problems, which may not be a bad way to go. In the words of the famous statistician John Tukey: "An approximate answer to the right problem is worth a good deal more than an exact answer to an approximate problem."

Matt Casey

I found that Edinburgh is a beautiful old city with a prominent towering castle atop a volcanic neck. From the castle, a street called the Royal Mile extends a mile and a quarter toward the Queen of England's palace. The Royal Mile is full of wool garment stores, secret passages, pubs and whiskey shops. Edinburgh also has many modern art and sculpture museums and is truly a unique place to explore.

The ETLP is sending two students to the Spring 2005 RCP meeting in order for them to see what we do and what life is like in Golden and on the front range. The next step is to organize an exchange for a semester or two. It is very exciting to be involved in cross-disciplinary integrated research and to collaborate with people from other parts of the world.

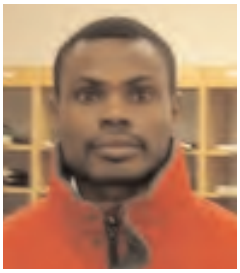
Edinburgh street scene

Crossing Borders

International students make up an important part of our department. These students are a long way from home and many of them do not return until after they complete their degrees. We asked a few of them to write how it feels to be in Colorado and at CSM.

Afolabi Babaloa

Homeland: Nigeria



Afolabi Babaloa

I was born in a small town called Akure, in Ondo State, Nigeria, into a family of six. Following my tertiary education in Akure, I gained admission to the Federal University of Technology, Akure, to study geophysics. My dad is an associate professor of physics there.

I am a very passionate and focused person with a lot of enthusiasm. I have a strong religious background, which motivated me to read lots of motivational books. These readings gave me insight into how life operates and the best ways to make it work on the road to success.

I am from a country where one has to struggle for everything. I have come to understand, however, that there are two things that make you in this world: the friends you make and the books you read. By books, I don't mean geophysics. I mean articles or books outside your primary area of academics that will inspire, propel and shape you for future challenges and opportunities.

I am always optimistic about life; and I dare never to give up on my dreams. I am a dreamer and I try as much as possible to see things from different perspectives. In fact, I prefer to take the road less traveled by others.

Before I decided to come to the United States, I researched in depth where in the world I could receive the best education. I chose the United States.

I studied Americans during my search and discovered that no other people in the world have such great self-esteem. I want to know the secret behind this, which added to my motivation to study in the States.

I chose CSM because the department of geophysics here has the best program in exploration geophysics in the world.

My plans for the future are to work in the oil and gas industry for a while, before venturing into consulting. I will be going into consulting because there are still many untapped mineral resources in Nigeria. For instance, Nigeria has the second largest deposit of bitumen in the world.

I also have passion for the people of my country; so I intend to go into politics in order to be an influence. I believe strongly that this is one of the best ways to affect the greatest number of people. Maybe one day I will be the first Mines alumnus to become a President.

Shahir Adnan

Homeland: Malaysia

Shahir Adnan

In January 2003, I packed my bags and came to the USA. Arriving alone, I didn't think I could survive without guidance and assistance. However, as time went by and I met a few people, I learned to do things on my own, and I *did* survive.

The first thing I noticed here was the weather; it is nice and not too hot compared to Malaysia. The second thing I noticed was the people and culture, which is very different from my own. The final thing that was hard for me was the loneliness of being away from my family and friends.

My experience studying abroad has made me a better person by opening my mind to new cultures, beliefs and ideas. As time goes by, I appreciate more and more seeing new things and meeting new people. With all the benefits of experience comes maturity. Beginning to learn about another culture and gaining global perspective and understanding is challenging, but also worthwhile.

I can't wait to graduate and pursue my career as a geophysicist. The geophysics department at CSM is great and the teachers are very helpful and wise. I am grateful for my friends who are always there and my family and my girlfriend who support me through my journey.

Flags are courtesy of www.theodora.com/flags. Used with permission.

The Leeds Trio

Homeland: United Kingdom

Helen Kershaw, David Thompson, and Tom Blanchard,

It is little things like finishing the last of the whole tube of toothpaste you brought with you, or needing a haircut, or driving on the wrong side of the road as if it were normal that make you realize you have been in a foreign country a long time.

We are three exchange students from the UK, who are half-way through our year abroad. This article is about our experiences of studying abroad, but first a little about ourselves.

We are all students from the University of Leeds in England studying for degrees in geophysical sciences. Tom Blanchard is from the Lake District in Cumbria. This is a damp, dreary place, which is one of the most beautiful areas of England. Tom plays rugby and enjoys winning at any thing at any cost. David Thompson is from Ripley, a midland town. Dave also plays rugby and is a cricketer for the University of Leeds. Helen is from Yorkshire, which naturally makes her a mean person (brutal in fact) and extremely tight with her money (never tips).

Our journey began in Leeds in November 2004 when we all chose which American University to go to. We all chose Mines. After weighing the pros and cons of each university, CSM stood out as the best educational and recreational choice. The school has a great reputation with employers in England and the Rocky Mountains have an even better reputation with the skiers and snowboarders.

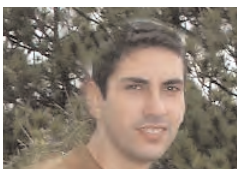
After the novel experience of buying a one-way ticket to another continent came the decision of what to pack. The essentials were obviously a guitar, a snowboard, and a jar of Marmite. Our first impressions of Colorado were of a hot, dry, flat, and above all, brown landscape, but the sight of the Rocky Mountains behind the Denver skyline took our breath away. (Although on reflection, this may have been the lack of oxygen.) Sunshine, also, was a strange new experience for us English people.

Leeds University itself has about 30,000 students and its School of the Earth and Environment is one of the largest in the country. Lectures can be in theatres with a hundred and fifty people, so arriving for classes of ten at Mines was a welcome change.

Being at the School of Mines has given us an opportunity to make new friends, see new places, and learn in a completely different teaching environment. When it comes time to leave, we will be looking forward to going home, but with great memories of Colorado.

Eldar Guliyev

Homeland: Azerbaijan



Eldar Guliyev

I arrived in Colorado from Baku, Azerbaijan, as an international student about two years ago. Golden, my "home" for the next two years, turned out to be a small, cute, western-style town, in a valley bordering the Rocky Mountains.

The city has two main sights: CSM and COORS brewery. At first it seems pretty boring, but Golden has its own charm. This peaceful town has proven to be the best place for me to study, relax, and enjoy the nice view. During my spare time I like to walk along Clear Creek, free my mind from any problems, and just let some philosophical questions about the meaning of life (for which I will never find answers) fill my mind.

The main difference between big cities and small towns are the people – here, the warm atmosphere can be felt everywhere. People living in Golden are kind, friendly and willing to help.

The surrounding nature and geographical location holds many opportunities for outdoor activities. I discovered for myself hiking, biking, kayaking and, of course, skiing, which was my first and most unforgettable experience with winter activities.

One might think, what is so unusual in all of this? I come from a country, where we hardly see snow or actual winter. My home town is a modern industrial city. Only after coming to Golden, have I appreciated the quietness of a small town and those marvelous views that Mother Nature created. I was amazed when one night I saw a deer in my back yard.

The seasons in Colorado are distinct. During the winter months the snow-capped Rocky Mountains are majestic and provide the best snow in the country for skiing or snowboarding.

Spring brings new beginnings when the snow starts to melt and fills the rivers and the creeks, trees blossom and birds begin chirping. When summer comes around, the weather is hot and dry — the time for vacations has come. I find that autumn is the best season in Colorado. The aspen trees in the Rocky Mountains glistening with golden leaves is a spectacular sight.

If you have never been to Colorado, I hope my description will inspire you to visit this beautiful, colorful state.

Ivan Vansconcelos

Homeland: Brazil

Ivan Vasconcelos on vacation in Spain.

I first came to CSM as a visiting student from the University of São Paulo, Brazil, to work with Ilya Tsvankin on an undergraduate thesis project. I was also using that opportunity to decide whether or not to pursue a PhD Little did I understand then the magnitude of the decision.

Going through the PhD program at the geophysics department at Mines has shaped, not only my professional character, but truly my entire life. It was here at CSM that I found my calling as a seismologist. I owe to my CSM instructors both my current knowledge and my interest in the problems of wave propagation in anisotropic heterogeneous media, parameter estimation and wavefield reconstruction in depth.

After perhaps a semester into the program, I came to realize that not only would I face technical challenges, but also the challenge of living a balanced life.

Thanks mainly to my parents' influence, I had a very diverse education that included not only school work, but also strongly emphasized the humanities and arts. As a result, I can never really detach myself from appreciating and performing some form of art.

Every day I face the task of dividing my time between research work and all the other things that equally matter to me.

At CSM, I've dedicated my free time to different activities. Playing the Great Highland Bagpipe, has always been a major interest, so I continued that hobby in Colorado. I even participated in solo competitions, which allowed me to formally rise through technical levels (called "grades" by the piping community).

I also joined the Mines Little Theater (MLT) drama group. During my two-semester participation with the group, I played a singing priest in a musical and directed two short one-act plays.

Performing was of course very fulfilling, but the best of MLT was the interactions with the great friends I made from the cast.

But the most refreshing experience for me is taking every chance I can to travel.

Max Peeters Appointed Dutch Consul

Professor Max Peeters and his wife Lilian.

Just when Max Peeters, Baker Hughes Professor of Petrophysics and Borehole Geophysics, considers retirement, he accepts another responsibility.

Max was appointed by royal decree of Queen Beatrix, Honorary Consul of the Kingdom of the Netherlands for the Rocky Mountain states of Colorado, Wyoming and New Mexico, effective June 1, 2005. Consul General of the Netherlands David van Iterson traveled to Colorado to administer the Honorary Consul oath to Max.

As Dutch Consul, Max carries out routine consular duties and attends official functions, as well as assists Dutch tourists who encounter difficulties. Max reports that though diplomatic license plates do not prevent speeding tickets, they do allow him to park wherever he likes!

Dutch Consul Max (and HM Queen Beatrix) in his Denver consular office.

A highlight for Max this year will be a meeting in May with the Prime Minister and the Queen during a consul conference in The Netherlands.

Meanwhile, on campus, Max is in the middle of what CSM calls "transitional retirement," which means he spends one semester each year with us, and we still get to enjoy his presence in the Department, as we complete the search for his successor.

Colorado – a Natural Place for a Norwegian to Visit

The Department has been pleased to have Martin Landrø from the Norwegian University of Science and Technology (NTNU) as a visiting professor for the 2005-06 year. Martin reports that he and his family, Ingjerd (wife), Heidi (17) and Helene (10) are enjoying life in Golden and in Colorado.

Ingjerd enjoys hiking in the mountains around Golden as well as the social neighborhood in north Golden. Daughter Helene had a hard time learning English for the first couple of months, but is now doing well at

Martin Landrø and wife Ingjerd at the Department's fall welcome picnic.

Mitchell Elementary School. She is also taking riding lessons as well as piano. Daughter Heidi is enjoying high school life at Golden High, and has been participating in the sports programs there. The Landrø's have two other children still at home in Norway.

Martin is working on several projects at CSM. One research topic is to estimate azimuthal changes in anisotropy utilizing critical seismic reflections. Other activities are to squeeze rocks in different ways with Mike Batzle and his co-workers in the Center for Rock Abuse.

Martin is particularly eager to measure the dilation factor of a compacting rock and to measure how CO2-injection changes the seismic properties of various reservoir rock samples. So far, two papers have been submitted during his stay at CSM, and the hope is that more will be completed.

"Norwegians love ice, rocks and water." – photo by M. Landrø

Martin allocates weekends for family time. The photo here is from one of the family hikes into the Rocky Mountains. Norwegians love ice, rocks and water.

The Department gained "two for one" with Martin's CSM visit. Martin's student, **Amir Ghaderi**, and his family are also spending the year at CSM as Amir continues work on his PhD thesis, "An integrated study of seismic monitoring of CO2-injection using laboratory measurements and time-lapse seismic data." He is in Golden with his wife, who is also at CSM as a postdoc in the Department of Material Sciences, and their three children.

Visiting student Amir Ghaderi and his children in a picture-perfect Colorado setting; but, where's the snow?

Studying Abroad

Where in the World is Wollongong?

– Stephanie Cook, GP Junior

"**Where?!**" This was the usual response I received when I told someone I was off to University of Wollongong, New South Wales, Australia, to study abroad for a semester. With such a strange name many thought I was off to the far reaches of the outback where you don't see anything but red dirt for hundreds of kilometers. But in fact, if you care to try your luck at driving on the left side of the road, the drive south to Wollongong from Sydney takes less than one hour.

Stephanie Cook

I instead arrived in Wollongong by train at nine in the morning, in the rain, totally exhausted, and immediately wanted to go home. That feeling quickly passed, however (unfortunately the jet lag didn't), as I was swept into orientation week and quickly immersed in Aussie culture.

By the time the session was over, I wanted to stay for another! I made incredible friends from all over the world – including some from Colorado, whom I had to go to the other side of the world to meet. Some of these friends have come to visit me already! I got to travel all over the place, including Tasmania and Fiji. I learned how to speak Australian (it really is a different language at times) and went to class every now and then.

I highly encourage everyone to study abroad – pick any country you want, your experience will be amazing.

North to Alaska

Sometimes our students travel, just for fun! GP grad student Lauri Burke (2nd from left) on a ten-day backpacking trip in the Wrangle-St. Elias Mountains in Alaska.With Lauri (left to right): Todd McFadden (PE alum, Lauri's husband), Lauri, Zack Bennet (EE alum), and Mike Schaardschmitt (EE alum).

Continuing Education

Learning (and teaching) Never Stop

Short Course Travels Long Distance

– Ilya Tsvankin

Professor Ilya Tsvankin and Vladimir Grechka (former CSM research faculty member, now with Shell) have been teaching a two-day Continuing Education Course for the Society of Exploration Geophysicists (SEG) since 2001.

The course, "Seismic anisotropy: Basic theory and applications in exploration and reservoir characterization," was in high demand in 2005 and continued to receive enthusiastic reviews from the attendees. Ilya and Vladimir taught the course for Petrobras in Rio de Janeiro, for the Bureau of Geophysical Prospecting in Beijing, at the Canadian SEG, "Doodletrain Education Week" in Calgary, at the SEG Education Week in New Orleans, and before the SEG Annual Meeting in Houston. Predictably, the largest crowd (60 people) gathered for the course in Beijing, where CSM graduate student Yaping Zhu helped with simultaneous translation.

The popularity of the course reflects the increased attention to anisotropy in the exploration community. For a long time, the seismic exploration method had operated under the simplifying assumption that the earth can be described by isotropic models. The fact that the speed at which seismic waves travel might depend on the propagation direction had been considered too complicated to be taken into account in exploration practice. Work over the past decade has led to a number of breakthroughs that show, not only how to correctly process seismic data in the presence of anisotropy, but also how to estimate the anisotropic parameters that carry crucial information about lithology and fracture networks.

In developing the course, Ilya and Vladimir tried to cut through numerous complexities of anisotropic wave propagation and focus on practical, physically intuitive approaches to anisotropic inversion and processing.

CSM PhD student Yaping Zhu with Ilya and Vladimir in Beijing.

The primary course handout is Ilya's book on anisotropy that sold out in 2004 and was reprinted last spring by Elsevier Science.

Teaching the course has been a two-way street for Ilya and Vladimir who have learned a lot themselves from the course attendees. They have also seen some spectacular sites and made new friends inspired by the course to join the anisotropic community.

Davis & Roche Share India Adventure

– Tom Davis

Tom Davis and Steve Roche (Veritas) travelled in January to Jorhat, India, to present a course on 4-D Multicomponent Seismic Reservoir Characterization. Sponsored by the Society of Petroleum Geophysicists of India, the course preceded the three-day Kolkata 2006 convention.

Steve Roche, PhD, CSM, 1997.

Jorhat is in a remote area of India in the extreme northeast, at the foot of the Himalayan Mountains. It reminded me of the Alberta foothills except for the rhinos, elephants, tigers, and lions. Needless to say, you didn't wander out of the compound without an armed entourage.

While we were teaching, my wife Pat, along with a driver and two armed guards, went to view the wildlife in a National Park. She was amused by the three burley men sitting in the front of the jeep, with herself as the only rider in the back seat.

The hospitality of the people was phenomenal. We were treated like royalty. Steve commented that the people don't rely on being entertained like we do in the US; they create their own entertainment. We spent one evening with people telling stories, jokes and singing songs – a real talent show. Steve quipped something about "trust me for an unorthodox adventure."

Of course, what brought Steve to Mines as a student, was our meeting in Chengdu, China, in 1990, during a similar experience with the Chinese. We look forward to our next excellent adventure, wherever that might take us.

Tom and Pat Davis at the Taj Mahal.

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Hearing from Far-Away Friends

Check Dam Project

Manika and husband Günter, saying 'hello' from Mumbai, India.

Manika Prasad, research professor with Mike Batzle's Center for Rock Abuse, is currently spending two years at the India Institute of Technology, Bombay (IITB) as associate professor of petrophysics. As she describes below, Manika is also involved in a volunteer project to build small check dams for rural water supply.

I am involved in a volunteer project to build small check dams for rural water supply. Note: in the state of Maharastra (Bombay belongs to this state), there is a lot of rainfall during monsoon. But, due to the topography of the region, most of the water is lost as run-off to the sea. The small villages suffer from chronic water shortage during pre- and post-monsoon months and severe soil depletion during monsoon.

I joined a group of civil engineers and soil conservation faculty to help build check dams to harvest rain waters. Since the work was done without any geoscience input, they had gotten mixed results. I requested student volunteers to help map fractures and geology of the area. Not only did most of IIT earth science students come, but we also got students from neighboring colleges! Now, I am not going there as often as the students – they have taken charge and ownership of the project! You can be involved in the project too! Check out: http://www.cse.iitb.ac.in/~ctara/

This village is the potential beneficiary of the dam project.

This is a successfully built dam that carries water for almost eight months! This water is useful for washing and for buffalos (and for the kids to play in). This image was taken soon after monsoon. Note the green colors – they will soon disappear.

The IITB Earth Science building (multiply by infinity any space and leakage problems in the Green Center at CSM).

In the valley proposed for the dam, students map the catchment area and make pits to assess subsurface lithology.

Welcome

Paul Sava Joins CWP and Geophysics Faculties

Paul Sava joined the Mines faculty in January 2006 as an assistant professor of geophysics. Coincidentally, Paul's main scientific interest is in computational methods for wave phenomena, and this makes him a natural fit for the Center for Wave Phenomena (CWP), with which he is currently affiliated. As an active member of CWP, Paul joins other faculty Dave Hale, Ilya Tsvankin, and Roel Snieder, as well as University Emeritus professors Norm Bleistein and Ken Larner.

Paul's main research interests include imaging and tomography, computational methods for wave phenomena and probabilistic inversion.

In the recent past, he has developed methods for modeling wavefield propagation in complex geology, imaging and velocity analysis using computationally-intensive wavefield methods. Not surprisingly, his favorite toys are large parallel computers.

Paul's teaching at Mines commenced on his very first day on the job. He is currently teaching "Introduction to Seismic Exploration." He enjoys teaching at the undergraduate level, because this gives him the opportunity to present seismic processing from an unconventional point of view, free from dated concepts and common jargon.

For the fall semester, he is planning to offer a graduate-level course on imaging methods, exploring connections between geophysical and medical imaging. He plans to approach this topic in an interdisciplinary fashion of interest to a larger cross-section of the CSM student population.

Prior to joining the CSM faculty, Paul was employed by the Bureau of Economic Geology at the University of Texas (Austin), where he was nominated as a Jackson Young Scientist Fellow. Before that, Paul worked on his PhD in geophysics at Stanford University, where he was affiliated with the Stanford Exploration Project, the friendly rival of his current research group, CWP.

During his student years, he received three awards of merit for best student presentations at the SEG conventions (1999, 2001 and 2004). He also received an honorable mention in the category Best Paper in Geophysics (2003) for "Angle-domain common-image gathers by wavefield continuation methods," co-authored by Sergey Fomel.

The Sava family: Paul, wife Diana, and daughter Iulia.

Paul shares the joy of being in Colorado with his wife and daughter, Diana and Iulia, who are the guardians of his honorable position of third-in-command of the Sava clan.

More information about Paul's teaching and research at

http://www.mines.edu/~psava.

Feng Su Brings USGS-Supported Program Opportunities

Feng Su (Suzie) and her husband Yuehua Zeng.

Feng Su (Suzie) joined the Geophysics Department as a research associate professor last fall, moving from Reno, Nevada, with her husband, Yuehua Zeng, and their daughter, Wendy. Her husband is a research geophysicist at USGS.

Before she came to the Colorado School of Mines, she worked as an associate seismologist at the California Geology Survey and as a research assistant professor at the University of Nevada, Reno.

Suzie's research interests are earthquake ground motion simulation and modeling and probabilistic seismic hazard analysis and application of space geodesy in geophysics. Her recent research work on probabilistic seismic hazards in Lake Tahoe, Nevada, was presented at last year's annual meeting of the Seismological Society of America. The work received great attention there, and was reported by over 50 newspapers nationwide. She is now continuing working on a seismic hazard analysis project through a contract with the National Seismic Hazard Mapping Project (NSHMP) at the USGS here on campus.

NSHMP is one of the most important programs at USGS. The national building codes, earthquake insurance policies, highway bridge designs, and many other related issues are all based on these maps. The updating to the next generation of the national hazard maps is due in mid-2007, and she hopes to recruit some talented students to work on the project.

She hopes that through close research interaction, the department and USGS will continue to build a strong collaboration, benefiting the programs for both and bringing multiple opportunities to CSM students.

A Geophysics Career *from* Multiple Perspectives

by John Mathewson, CSM alumnus & MS Student

In 1981 I graduated from CSM with a BSc in geophysics. Now it's 2006 and I'm back, working on an MSc, again in geophysics. There are still a couple of familiar faces around, like Professors Tom Davis and Terry Young, whose classes I attended – way back when.

The years since I first left Mines have been pretty enjoyable. One of my great joys is travel, and this is one of the reasons why I chose a geophysical career. Geophysical exploration often involves going to some parts of the world that you would never see otherwise. In my case, the means to this end was a career with Western Geophysical.

CSM student John Mathewson with family: wife Mary Ellen, LIbby (13), Ian (15) and James (6).

Before that, however, I went directly from school in 1982, to the offices of Amoco in downtown Denver. That was a fun year learning about the oil business, but the job was not to last. In 1983 there was radical downsizing in the exploration business and a lot of us were looking for jobs again. I packed all of my belongings in the car and headed for Houston, where Western Geophysical offered me a job in marine data processing.

I learned quite a bit there, but I really wanted to get out and see the world. So I talked with some people in land seismic acquisition. A month later, I was on my way to Tanzania, where I would be working on an infield data processing system. At the start of the job, we made a six-day camp move from Dar-es-Salaam to Lake Rukwa, waving at all the people in the villages, enjoying the spectacular scenery. Part of our journey was through a game park, where we saw giraffes, zebras, warthogs, and elephants. Once we arrived safely at Lake Rukwa, we stayed for about a year.

When the project finished I was transferred to Yemen, where my job was Infield QC, calculation of refraction statics (by hand on graph paper!), and collecting uphole data. The crew was shooting 2D seismic in the area around Marib, which is the city where the Queen of Sheba lived. During her time, there was a city there with a population of around 200,000. They created a large reservoir back then and you can still see the old dam. The area is now desert, with quite a few bedouin tribes around, and it is possible to see ruins and rock carvings.

You have to be very careful working in Yemen. The Yemenis that worked with us would not go anywhere without their AK-47's. However, we never had any serious problems. I think it's important in such situations to be polite and attend to your own business.

After several months in Yemen, my next post was again in the desert, this time in Jordan. In Jordan, I was once again doing data processing, refraction statics – using a computer this time! I was fortunate to work there with a couple of friends from Mines, Todd Fockler and Clark Capes. Jordan was more civilized than Yemen, though not as exotic. The desert there consists of endless gravel plains, so it's easy to get lost. Still, you'd be surprised how many people travel the desert. If you're patient, someone will come along eventually and you can ask for directions.

The really big event of the year in Jordan was meeting my wife, Mary Ellen. It's a long story, but we met at a wedding (of course) and fell in love. After two weeks together, I returned to the crew. We communicated via letter for two months until my next break. We then got engaged, spent three weeks together, and I returned to the crew again. Two months later, another break, and we were married. After our honeymoon she went to Syracuse, I went to Jordan! After my final stint on the crew she came to Jordan and I drove her across the desert to the crew. All the boys were surprised to see her, and she was very pleased to see where I'd been all this time.

Now that I was married it was no longer an option to work on a seismic field crew, so I had arranged an office job working in Houston, data processing again. We made it about a year until we needed to get out again. I managed to transfer to the London office to work in land data processing.

I missed the seismic crew, of course, but the work in London was interesting. For the first time, I was able to work with 3D seismic data, a great improvement over 2D work. I started to take an interest in the technical aspects

of geophysical data processing.

I was in the London office for four years, running a data processing group by the time I left. One thing I enjoyed there was working on data from all over the world. We used to get work in from Nigeria, Europe, Turkey, Africa – all over the place. Every particular area had its own problems where some things worked or didn't. But, when you are learning a trade, this kind of experience is better than seeing the same thing over and over.

At home our situation had changed. Our son Ian was born about a year after we arrived there. Our daughter Libby came along fifteen months later. Mary Ellen became a full-time mom. I learned how to feed babies and put them to sleep. Things were going very well when the travel bug hit again. I called Gary Jones, VP for South America. He asked if I would like to join a field crew in Bolivia.

Soon I was on the field crew on the altiplano, and Mary Ellen and the kids were living with her parents. I worked on that project at 4000m above sea level for about four months, then on to another project in the swamp. My job was still infield data processing and QC. In fact, the altiplano job was running the first installation of Western Geophysical's Omega system, so it was fun working the bugs out of that.

Every few weeks I'd head up to the States to spend three weeks with my family. Definitely, this long-distance thing would have to end. Mary Ellen and I decided that they would join me in Bolivia. They all loved it there.

I was working on a new project in the Villamontes in the south of Bolivia, when Gary Matyas arrived on the crew and asked, "So, you know how to process 3D seismic data?" Soon thereafter the family found itself in a dumpy apartment in Buenos Aires, eventually moving into nicer digs across from the Bosque de Palermo.

Buenos Aires is a great old city. I used to ride the no. 12 bus to work every day. The kids got very good at handling themselves around traffic, and they're still with us. We used to love wandering around the city. During the week I was working hard as a supervisor at the data processing center, where we had some very interesting overthrust work. For the first time, the subject of prestack depth migration came up. I got a kick out of discussing PSDM and other technical issues with clients in my pidgin Spanish.

John at a bar in a Bolivian village where the beer was warm due to no electricity. This spot was a beautiful seven-hour trip from the nearest road in a motorized dugout canoe.

Bolivia was then heating up a bit, as a pipeline to Brazil was under construction. We opened a processing center in Santa Cruz, which I was to manage. We moved a computer system there and were open for business. We did quite a bit of 3D time processing, and some 2D PSDM. The PSDM work was very challenging on the overthrust data, and we achieved some good results, in spite of being only a small center in Santa Cruz, Bolivia.

After a year or so, the market in Bolivia cooled down and we decided to move once again. Fortunately, the London office was looking for an Area Geophysicist. Soon we were back in England, and James was born a year later. I don't know what it is about the place, but if we had stayed in England we'd probably have ten children.

The position in London involved solving various technical problems for the production processing groups working there. My specialties were in noise attenuation and statics for the land groups, and multiple attenuation (particularly SRME) for the marine groups. I also supervised projects such as a large OBC offshore Nigeria.

It was soon time to move again. By this time my family was feeling it was time to settle down a bit. We couldn't really afford to live in London. I spent a couple of short stints in Abu Dhabi (very interesting for multiple attenuation) and Assen (dedicated center at NAM). Fortunately, then I was invited to transfer to Calgary.

I worked in the Calgary office as Area Geophysicist and then as Depth Imaging Supervisor. I found the Arctic data very interesting. We studied noise attenuation and statics in permafrost areas. Later I spent most of my time working on PSDM in the "Canadian Foothills," which involved TTI anisotropy.

In the meantime, my family had settled in nicely in Bragg Creek, west of Calgary. We learned to dress warmly in winter, and my children started talking like Albertans. We enjoyed Canada a lot, and hope to return someday.

While I was in Canada, I began to feel that it would be a good idea to go back to school and try for another degree in geophysics. I had come pretty far in my career with a bachelor's degree, but I felt that more opportunities would be available if I were to have more education. Throughout my career, I have repeatedly found myself in technical positions, rather than managerial, and I continue to work as a hands-on geophysicist.

I felt that one of the best places to work towards another degree in geophysics would be CSM. Our Denver office said they'd be glad to have me. We moved to Golden in August 2005 and I started my new double life, working downtown for WesternGeco as a depth imaging supervisor, and studying part time at CSM.

Last semester I took the Digital Analysis class, which did a good job of kick-starting my brain – definitely my mathematical skills need more practice. Anyway, we will continue on with this. I feel very optimistic about the future, and am looking forward to the further challenges of research at CSM.

INTERNSHIPS
A GLIMPSE INTO THE FUTURE

The Study of Water

– Kristen Schmidt, GP Junior


Kristen Schmidt

Hyporheic zone? Thalweg? Rhodamine? These were just a few of the hydrologic terms that I learned over the summer during a chance to apply geophysics to solve problems in hydrology as a field technician. I worked in the field with Dr. Michael Gooseff, assistant professor of Geology and Geological Engineering at CSM.

We spent the first week in western Montana at the Tenderfoot Creek Experimental Forest. This was a field reconnaissance trip during which we spent time walking up and down small streams discussing what type of experiments should be performed. I learned how to perform a tracer experiment with salt, a method used to determine if the stream is gaining or losing water.

We left Montana for the Sawtooth Mountains in Idaho. At the field site there, we were hoping to test methods to image the hyporheic zone, which is an area under the stream where a mixture of surface water and groundwater is located. We used ground penetrating radar (GPR) and resistivity measurements to detect stream tracers of dissolved salt in the hyporheic zone.

We also performed experiments along the scenic Springs Creek, which flows into Bull Trout Lake. There we spent several long days setting up, performing, and taking down the experiment. During this time I ran up and down the stream doing a little bit of everything, such as taking resistivity measurements, helping with the cross-borehole equipment, collecting water samples, and stirring up the giant trash can of rhodamine and salt used for the stream tracer.


The results of rhodamine and salt used for the stream tracer.

When the field work was over, I returned to CSM to filter and measure the water samples that we had taken in the field. I saw all of the hard work in the field turn into information that we could use for interpretations.

I learned that I enjoy hydrology and hope to be able to combine this subject with geophysics. Like most people, I believe that water issues will increase in importance, and I would love to be involved in that field. I also learned the difference between reading articles on the subject, and performing experiments. Out in the field, there is a passion and understanding that a person can't get just by reading.

Baseball and the Real World

– Yaping Zhu, PhD Student
Center for Wave Phenomena (CWP)


Yaping Zhu

My internship with ExxonMobil in Houston over the past summer was a positive experience for both my PhD study and for my future career

I worked with the Reservoir Characterization Division on seismic forward modeling of fractured rocks and was financially supported by the Sub-Surface Imaging Division. This gave me the opportunity to interact with both groups.

Though going into the internship, I felt much anxiety, fortunately the project progressed smoothly, thanks to the group's carefully designed plan. My mentor, supervisor, project manager and other team colleagues were always supportive. I found that good communication is highly appreciated within ExxonMobil. During monthly presentations, I received constructive suggestions for improvement, just as we typically experience during the rehearsal sessions for CWP.

I appreciated the unique opportunity of the internship, not only because of the high caliber team that I was working with, but also because of the exposure to the company's culture, which is quite different from that of academia. I cannot say how much progress I made in such a short period, but I did see that I was growing.


Yaping's ball game vantage point.

I was impressed with the challenging project that I worked on, and also by the intern activities coordinated by the company. Through a series of intern forums, we learned about each other's projects, often giving us better ideas about our own work.

The intern work was supplemented with extracurricular activities, such as a Houston Astros baseball game. I don't yet understand much about the game of baseball, but I was fortunate to make a "home-run" with a job offer kindly extended from the company, to begin following my thesis defense this spring.

When I stepped into the company office as an intern student the first day, I felt timid. When I stepped out of my office the last day, I felt excited, proud, and confident of my career.

California Pastime

Predicting Earthquakes

– Lia Martinez, GP Junior

Lia Martinez

After packing my car and driving the 1001 miles from Golden to Fullerton, CA (in Orange County), I was a little nervous about making a good impression during my summer internship with the Southern California Earthquake Center (SCEC). The previous semester, after applying to their undergraduate research internship program online, I had been accepted and assigned to work with my mentor, David Bowman, at California State University, Fullerton. But as excited as I was to participate in some of the most cutting-edge research in earthquake seismology, my fears got the best of me- shouldn't I have taken at least *one* class in seismology first?

In actuality, I didn't need previous seismology experience. Under the mentorship of Dr. Bowman, I learned about the current theories of earthquake prediction, including Accelerating Moment Release (AMR). AMR, in a basic sense, means that before M7+ earthquakes, a period ranging from 10 to 40 years occurs wherein there is an increase in the seismicity surrounding the fault.

Lia atop San Jacinto Mountain during an intern retreat.

My job for the summer was to apply a method of determining AMR created by Dr. Bowman to all of the major faults throughout Southern California (the Southern San Andreas, Elsinore, and San Jacinto), and thus try to predict upcoming Magnitude 7+ earthquakes. By "upcoming", I mean in the next 5-10 years. Even though this required a lot of staring at a computer screen, the actual research was very engaging.

The Southern California Earthquake Center is comprised of a conglomeration of universities and professors from around the country with the mission of gathering new information about earthquakes in Southern California. It is funded by the NSF and USGS. Every year, SCEC funds approximately 30 undergraduate interns from around the country to work one-on-one with some of the world's preeminent earthquake scientists.

Although working with just one professor all summer may sound like a lonely experience, I was constantly meeting new people, making new connections and being asked to participate in other projects. For example, Jim Nolan, a friend of my mentor, knew a graduate student at USC who needed volunteers to help her perform a seismic survey in Compton for a week. Suddenly, I found myself working with Harvard undergraduates and graduates lugging around geophones and swinging a sledgehammer for days on end. It was one of the best experiences I had all summer.

Not only was I meeting people outside of the program, but SCEC also arranged for multiple intern events. In June, we had an Intern Retreat in the Idyllwild area of the San Jacinto Mountains. During the retreat, we were taken on field trips to San Jacinto Mountain and both the San Andreas and San Jacinto Faults where seismologists working in the area described to us the location's geological history and their current projects.

In July, most of the interns attended a weekend trip to the University of San Diego and made multiple trips including one to see Scripps's Oceanic Observatory. In August, SCEC organized an Intern Research Colloquium where each intern presented and discussed his or her research with the group.

When I returned home to Golden in August, I couldn't wait to tell everyone about the work I'd done and my new theories regarding which major Southern California fault will be the next to break (The Big Bend of the San Andreas). But I still wasn't done. In September, SCEC flew all of their interns back from their respective institutions to attend the Annual SCEC Conference in Palm Springs, CA. There, we presented our summer research in posters of our own creation and fielded questions from many of the leading scientists in the field. Most of the time, the scientists didn't realize I was an undergraduate intern, and instead probed my work for weaknesses as if I were a graduate student. I quickly learned how to defend my work with confidence and was able to see other current seismological research.

Now back in Golden for good, I miss the friends I made while doing the internship and am thankful for the research that taught me so much about an area of geophysics in which I had no previous knowledge.

The 2006 Visiting Committee

We periodically welcome to campus a distinguished group of experts appointed by the CSM Board of Trustees as our Visiting Committee. While on campus, this group closely interacts with geophysics students, staff, faculty, and members of the administration in order to advise us of any areas of needed improvement. We are grateful to this group for taking an interest in our goal to provide the highest quality education in geophysics.

Peter Annan, President
Sensors & Software, Inc.

Craig Beasley, Schlumberger Fellow, WesternGeco

Rutt Bridges, CEO,
The Bighorn Ctr. for Public Policy

Dave Cooper, Development Geophysicist, EnCana Oil & Gas

Richard Degner, Pres. & CEO,
Global Geophysical Services

Jerry Harris, Chr.,
Geophysics, Stanford University

Erec Isaacson, Mgr.,
Proj. Authorization, ConocoPhillips

Gary Jones, Chairman,
Arkex

Rob Kendall, Sr. Tech. Advisor,
Veritas GeoServices Ltd.

Jane Long, Dir., Energy & Env.,
Lawrence Livermore Natl. Lab

Jill McCarthy, Chief Scientist
Geologic Hazards Team, USGS

James Payne, Chr. & CEO,
Shona Energy Co., LLC.

Barbara Romanowicz, Chr.,
Earth & Planetary Sci., Univ. of CA, Berkeley

Anne Sheehan, Professor
Geological Sci., Univ. of Colorado

Jonathan Sheiman,
Geophysical Consultant, Shell

George Wood,
President, Sercel Inc.

SEG Honors and Awards for CSM

Norm Bleistein Awarded Honorary Membership in SEG

Norman Bleistein, CSM University Emeritus Professor and Research Professor of Geophysics, received the Honorary Membership Award from the SEG during the 75th Anniversary Meeting in Houston.

In the words of Sam Gray, author of the award citation, "Norm has long promoted a rigorous approach to seismic imaging problems, and his efforts have heightened our appreciation for the intricate relationships between mathematics and the physics of seismic wave propagation. Norm has excelled at communicating his ideas and his passion to generations of students and industrial colleagues. He has been generous in recognizing the contributions of others, and in bringing academic research groups closer together. And he has done it all with an infectious sense of joy."

Among his credentials, Norm is founder and former director of the Center for Wave Phenomena at CSM, which is recognized as one of the most successful industry-sponsored consortia. Norm's "tireless energy and selflessness continue to have a dramatic impact on technology, students, colleagues and friends."

Terry Young Selected SEG President

– Craig Beasley, Outgoing SEG President

November 10, 2005, was a day that loomed large for GP Department Head Terry Young, and it was no less important for me. Not to be too precise, but at 1:00 PM CST on that day, I passed the responsibilities of the SEG presidency to him.

Terry has had a lot of experience with the events and customs of the SEG, so he took the whole thing in stride. His time spent in various SEG activities, such as serving as Secretary/Treasurer and then as member of the Finance Committee, as well as being General Chairman for the 74th Annual Meeting held in Denver, have been excellent training for the job. With his year as president elect, Terry is likely better prepared for the job than many have been, and I was pleased to hand the office to him.

I can't predict what will happen during Terry's year, but I expect that you will see less of him on campus because of the many meetings he will be attending. The office of SEG President is highly respected worldwide and I know that Terry's travels will bring honor and recognition to CSM and to the GP Department.

I would like to say "thank you" to Mines and to the GP Department for encouraging Terry to accept this job, and for donating his time to the Cause. Terry, you won't need it, but good luck, anyway!

Best Poster Paper

Michael Batzle, et al.

Mike Batzle

Research Professor Michael Batzle and co-authors Brian Zadler, Ronny Hofmann and De-hua Han were awarded Best Poster Paper Presented at the 2004 Annual Meeting for the paper, "Heavy oils: Seismic properties."

Best Student Paper

Richard Krahenbuhl

Rich Krahenbuhl

Postdoc Rich Krahenbuhl was awarded Best Student Paper Presented at the 2004 Annual Meeting for his paper, "Hybrid optimization for a binary inverse problem."

Award of Merit

Paul Sava

Paul Sava

Asst. Professor Paul Sava received the Award of Merit (Best Student Paper) for the paper "Wavefield extrapolation in Riemannian coordinates." written as a student at Stanford University,

Distinguished Volunteer

John Stockwell

John Stockwell

Research Associate John Stockwell was honored as 2005 Distinguished Volunteer for his creation of the "Geoscience-Geophysics-Petroleum Industry Timeline" poster.

GP Year in Review

Fall 2005
Welcome Picnic

GP Day
Picnic...

Celebration of Mines 2005

...and Banquet

Grad Student
Retreat 2005
The Nature Center
Florissant, CO

Enjoying Retirement

The Youngs check in with the Alex Kaufmans in California.

Kasper & Mila Wed

Research Assistant Professor and CSM alumnus Kasper van Wijk, and PhD candidate Mila Adam were wed Summer 2005 in Caracas, Venezuela, with several CSM colleagues in attendance.

At left, Kasper and Mila in their more usual surroundings.

Kasper has accepted a position as Assistant Professor in the Department of Geosciences, Boise State University, beginning Fall 2006.

Heiland Lectures

Geophysicist and adventurist Pasquale Scaturro was just one of our invited speakers. Pasquale spoke of leading the first expedition down the Blue Nile from source to sink; a trip documented in an IMAX film.

Meng Ersheng, CSM Honorary Degree, December 2005

Meng Ersheng, referred to as the "Ambassador of Geophysics to China," attended CSM in 1948 before being recalled to China due to impending civil war. During his very active career (a portion of which he was chief geophysicist of BGP), he promoted geophysical industry interaction between China and western companies.

Anniversaries

GP Office Manager Sara Summers receives 25-year Award from CSM President Trefny (above); Michelle Szobody, CWP Program Assistant receives 15-year Award as a State employee (left).

Playoff Madness: Broncos vs. Steelers

GP student Kris Davis – a brave fan in Broncos territory!

Job Opportunities:
A Road Less Traveled

TAMARA GOES TO WASHINGTON

Opening Doors for Geophysicists

– Tamara Gipprich

I never thought of myself as one who would eventually enter the oil industry upon finishing my master's degree. So why, you ask, did I join the geophysics department at CSM? I've realized the answer is that I was trying to find my niche as an earth scientist and explore a wide range of career options. I came to CSM in 2003 with a geology background and a fascination with natural hazards, remote sensing and mapping technology.

My time at CSM has opened doors for me that I never would have imagined. Upon my arrival, I was offered a project working with Space Imaging, a commercial remote sensing company. During that experience I learned techniques for analyzing satellite imagery and I wrote an article published in *Imaging Notes* magazine entitled "Monitoring Colombia's Pipeline Infrastructure – Observing Theft from Colombian Pipelines."

I also worked for the USGS while attending classes and starting my thesis research. This job gave me experience in Geographic Information Systems (GIS) and an insight into the research process of the federal government.

Finally, my master's project, "The Dynamic Triggering of Landslides," helped complete my goal to expand my knowledge of natural hazards.

To my surprise one day, I was contacted about interviewing for a scientific position at a large US government agency. In recent years, the mix of geophysics, geology, mapping and imagery skills has become highly attractive to homeland security agencies and these positions continue to be in high demand. After extensive background investigations, I was granted a once-in-a-lifetime job opportunity with this agency.

Even though I started my degree at CSM without knowing where it would lead, I feel that I have finally found my niche and an experience that I could not pass up. I encourage other students to grab opportunities that will expand their experience in geophysics – it may lead to the unexpected!

You may not see my name in headlines, or as the next 007, but be assured that following my education at CSM, I have the ability to help protect our country.

Tamara Gipprich was awarded a CSM master's degree in geophysics December 2005. She submitted this article just as she was beginning her new job in Washington DC (exact location not disclosed).

Tamara with her thesis advisor Roel Snieder.

g·r·a·d·u·a·t·i·o·n 2005

Bachelor of Science

Luke Constant Bernhardt
Salman Khalid Bubshait
William Andrew Burnett
John Constantine Chakalis
Kristofer John Davis
Muhammad Firdaus Mohd Fuad
Matthew David Gardine
Brian Douglas Grade
Mason Andrew Kass
Jared Roy Peacock
Emily Carlson Roland
Paul Conrad Schwering
Armando Jose Sosa
Sarah Katherine Thompson
Hunter Anne Yarbrough

Doctor of Philosophy

Pawan Dewangan
Matthew Mattson Haney
Richard A. Krahenbuhl
Alison E. Malcolm

Master of Science

Ramzy M. Al-Zayer
Hasan Hasan Asgarov
John Leif Colson
Hans Ecke
Tamara Louise Gipprich
Kjetil Jansen
Mahendra A. Kusuma
Nicole Marie Pendrigh
Eugenia Maria Rojas
Firuz Avaz Salamov
Jessica Marie Schwark
Sarah Elizabeth Shearer
Frederic Dje Youan

PhD Alison Malcolm and Advisor Martijn de Hoop

Who are they kidding? PhD Matt Haney and Advisor Roel Snieder

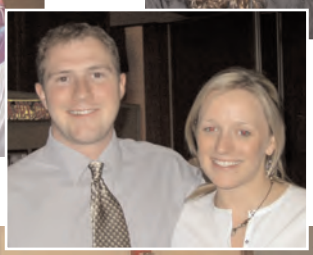
Kris Davis, Salmon Bubshait & Matt Gardine

Hunter Yarbrough, Paul Schwering & John Chakalis

Sarah Shearer

Emily Roland

Firuz Salamov & Family



Will Burnett & Sarah Thompson

Back row: Brian Grade, Frederick Youan, Rich Krahenbuhl, Tamara Gipprich, Jessica Schwark. Front row: Armando Sosa, Eugenia Rojas, Hans Ecke, and Andy Kass.

Mahendra Kusuma

PhD Rich Krahenbuhl and Advisor Yaoguo Li

GP Faculty Retreat

Annual Planning Session Reinforces Team Effort

The faculty gathers informally each summer to do strategic planning in a relaxed setting. This year it was a pleasure to welcome new faculty members Paul Sava and Lizet Christiansen, as well as Paul's wife, Diana who is also a PhD geophysicist.

Welcome to incoming faculty: (upper far right) Paul and Diana Sava, along with Lizet Christiansen (right) , arriving August 2006. Terry Young (far right) presents department gift to the faculty.

Faculty (front row) Terry Young, Diana Sava, Lizet Christiansen, Misac Nabighian, Adel Zohdy, Yaoguo Li; (back row) John Stockwell, Bob Benson, Roel Snieder, Norm Bleistein, Dave Hale, Paul Sava, Ken Larner, Steve Hill, Gary Olhoeft.
Faculty not pictured: Mike Batzle, Tom Boyd, Tom Davis, Warren Hamilton, Pieter Hoekstra, Tom Lafehr, Ilya Tsvankin, and Kasper van Wijk.

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