geophysics

Spring 2001

Colorado School of Mines

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A Note from the Department Head

Greetings from Golden! After a year at the helm, I am more enthusiastic than ever about the Department of Geophysics! Although this newsletter can capture only a small sampling of the outstanding people and exciting programs here, I hope it succeeds in conveying the excellence and esprit that make CSM such a special place. The Department of Geophysics comprises a healthy balance between undergraduate and graduate programs, and between educational and research activities. The photos and articles on the following pages provide some highlights.

If you will be in the Denver area in early May, please plan to attend our geophysics reception immediately following the graduation ceremony on May 4th. The reception is intended for our entire extended family—not only the honorees, relatives and friends participating in graduation, but also current students, faculty, staff, and alumni young and old. Drop us an email (tkyoung@mines.edu, ssummers@mines.edu) and let us know you're coming; it will help us to plan.

For those of you attending this year's SEG meetgin in San Antonio, we hope you will come to our CSM luncheon there. Look for more information about these events inside the newsletter.

Thank you for your continuing interest, involvement and support in the life of our department.

— Terence K. Young

Cover Photo by John A. Scales
taken of the Collegiate Peaks,
Buena Vista, Colorado

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Field Camp Traditions Live On at CSM

Field camp is one of the great traditions in the Department of Geophysics. For undergraduates, field camp often provides some of the best experiences and memories in their geophysical engineering program. For years our friends in industry have made large donations of field equipment that we have used not only in field camp, but also in laboratory instruction and graduate research. However, as time passes and the equipment gets older it becomes difficult and expensive to maintain.

Last summer, thanks again to our friends in industry, we experimented with a different approach—with great success. Veritas, in partnership with Talisman, provided a state-of-the-art Vibroseis system and a crew to operate it! Sercel donated a recording system and then sent along an expert to help run it! Harvey Klingensmith (Sr. Vice President, International Exploration, for El Paso Production) and his wife Seane, Mo Crous (Manager of Exploration Technology for Talisman), and our friends at the company formerly known as ARCO—by way of the SEG foundation—helped underwrite the venture.

This summer, Veritas, Talisman and Sercel plan to partner with us again to provide a first-rate field experience for our students. We are grateful for the generous support and involvement of these companies!

Upper picture: Students attending field camp during Summer 2000 are shown atop a Vibroseis system provided by Veritas and Talisman. Lower picture: Students Angie Southcott, Ted Royer, Holly Hindle, Whitney Trainor, and Suzie Moore take a short breather.

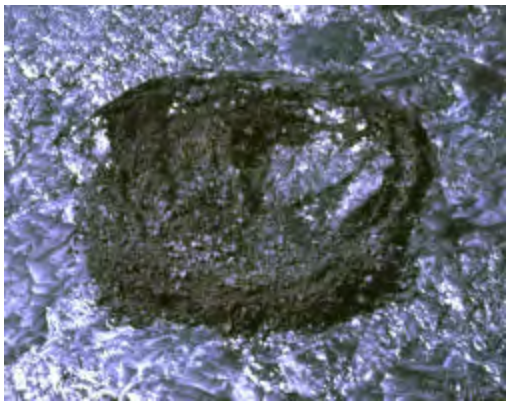
Group Studies Volcanoes in Hawaii

by Gary Olhoeft

In the summer of 1999, a group of students and faculty traveled to Hawaii as part of Geophysics Field Camp. On the Big Island of Hawaii, in cooperation with the USGS, the CSM students worked within Hawaii Volcanoes National Park. They collected data over hot lava tubes near a shatter ring with molten lava running a meter beneath their feet, over and inside a cold lava tube, and between the cold tube and the surface.

They also collected data at the site of an ancient Hawaiian village archaeological site and at the world class xenolith deposits on the Hualalai Ranch.

Undergraduate student, David Sinex, won a competition to travel to the Eighth International Conference on Ground Penetrating Radar, GPR2000, in Australia during May 2000 to present the Field Camp results. Some of the details were published in the conference proceedings. The paper, "Hot and cold lava tube characterization with ground penetrating radar," can be found on the Web at http://www.g-p-r.com/GRP2000B.pdf.



Upper: *Aerial view of a 60 m diameter shatter ring. Hot lava flows under the ring from upper right to lower left.*

Left: *This CSM group on the 1999 GPR survey in Hawaii includes Erin Wallin, Markus Lagmanson, Dave Sinex, Stefany Lewis, Brian Clark, David Stillman, Prof. Kathy Sander and Prof. Gary Olhoeft.*

Graduate Students and Faculty Bond Through SGGS Activities

by Marty Terrell, SGGS President

Graduate students come to CSM from all over the world with different cultural backgrounds, experiences, and interests. The students' research activities span a broad range of geophysical methods and applications including theoretical and applied seismology, gravity, magnetics, electrical methods, ground penetrating radar (GPR), rock physics, and borehole geophysics relating to the environmental, petroleum, and mining industries. The Society of Geophysics Graduate Students (SGGS) draws these students together through department-wide social activities including the weekly post-Heiland gathering, and barbecues with volleyball and other fun and games.

Graduate students and faculty look forward to the weekly social hour following the Heiland Seminar. Pictured here (left to right): Phil Brown, SGGS vice president; Ed Jenner, SGGS former president; and Marty Terrell, SGGS president. Not pictured is SGGS treasurer, Matt Haney.

The SGGS communicates a graduate-student perspective to the faculty on important issues. The president of the SGGS serves on the five-member Graduate Advisory Committee (GAC) providing input on matters ranging from student applications to teaching requirements for Ph.D. students. This position is a unique bridge between students and faculty that promotes cooperation and trust.

The Society assists students in various ways. A new activity, which is being organized for launch this Fall, is a mentoring program. Graduate students will mentor undergraduate students with similar interests. They will also introduce incoming graduate students to the department and the Golden area.

Historically, SGGS has administered financial support for students to attend professional conferences. This funding comes from the generous donations of companies and individuals. This year we were able to support several students to attend the SEG and SAGEEP conferences, and to establish an EEGS student chapter in the department.

The SGGS helps foster a community of learning in the department, contributes to the academic and professional development of its graduate students, and promotes strong personal friendships. We welcome suggestions, and donations from alumni and industry to help make the Geophysics graduate program at CSM both valuable and memorable.

Marty is a Ph.D. student working under Prof. Tom Davis in the Reservoir Characterization Project.

Society of Student Geophysicists

The Society of Student Geophysicists (SSG) sponsors bi-monthly luncheons and participation at professional society meetings for the undergraduates, and organizes the annual GP Day for the entire department. Pictured here are SSG officers Holly Hindle (Treasurer), Suzie Moore (Vice President), Amy Walker (President), Sarah Shearer (Secretary) and Joe MacGregor (Webmaster).

Undergrad Experiences Study Abroad

by Whitney Trainor

Whitney's version of "running with the bulls" in Pamplona, Spain.

Sometime in the middle of my junior year, I realized how quickly the grown-up and responsible "real" world was approaching. I had to react fast. The opportunity to study abroad and become fluent in Spanish (something I had always wanted to do) would be much harder after receiving my bachelor's degree. So I made the scariest and best decision in my life by studying in the Basque country in northern Spain for the fall semester of my senior year.

I remember reading numerous comments written by exchange students about how amazing their experiences were—and before my trip, they always sounded repetitive and trite. However, now I understand. To put the most influential, eye-opening, and awesome experience of your life into words is incredibly difficult. The only thing I would change about my decision to study abroad for the semester? Stay the entire year.

Whitney is a senior in the undergraduate geophysical engineering program.

1998 GP Grads

B.S. Degree
Royce Cameron Beck
Tammy Louise Campbell
Natalie Elaine Dotson
William Todd Faulkner
Edward Michael Fiedler
Evan-Pierre Bernard Genaud
Michael James Miller
Summer Brooks Montgomery
Brian Lee Mossberger
Michael Glenn Northrop

M.S. Degree
Barry Alan Kirkendall
Ekaterini Papakonstantinou
Alberto Villareal

Ph.D. Degree
Brian C. DeVault
Herman Jaramillo
Bruce William Mattocks

The Ice Skating Follies is a popular annual department event. Held at Evergreen Lake, the attendees are invited to warm up after the skating at the nearby home of Professor Ken Larner and his wife Nancy. Pictured here are undergraduates Whitney Trainor, Suzie Moore and Amy Walker.

Senior Justin Modroo displays his own version of airborne geophysics during a freestyle skiing competition.

CSM Graduate Women "Rock" with Summer Camp Youth

by Kate McKinley and Erin Wallin

The Association of Women Geoscientists and the Homestead Girl Scout Council of Nebraska invited women from our department to spend several days last July at Ashfall Fossil Beds State Historic Park to teach Girl Scouts about geophysics. These few days were part of "Nebraska Rocks," a summer camp for Girl Scouts, ages 13 to 17 who are interested in earth sciences.

These skeletons, including a female adult rhino and her calf, were excavated over the past several years. They are representative of what the Girl Scouts looked for with their ground penetrating radar survey at Ashfall Fossil Beds.

Not wanting to miss an opportunity to work in hot weather, the two of us loaded as much ground penetrating radar (GPR) equipment as would fit into a non-airconditioned car and drove nine hours to Northeastern Nebraska. Fortunately, many of the rest areas along I-76 and I-80 had their sprinklers watering the grass, and we were able to use them to stay cool.

Girl Scouts enjoy pulling ground penetrating radar antennas centimeter by centimeter.

Ashfall Fossil Beds are composed of a volcanic ash from eruptions in Southwest Idaho approximately 11.9 million years ago. The area of interest is believed to be a prehistoric pond, where rhinos and other animals came to drink and feed. After the eruptions, an ash cloud blew over what is now Northeast Nebraska filling in the pond with a few meters of ash and, over a period of several weeks, suffocating the animals that lived there.

To date, over 100 prehistoric skeletons of rhinoceros and other vertebrates have been excavated at the site. Our goal was to show the Girl Scouts how GPR could be used to locate the buried skeletons, and to discuss opportunities for women in geophysics and other earth sciences.

The Scouts were wonderful to work with. They took responsibility for laying out the survey lines, locating the survey lines relative to fixed locations, setting up the GPR antennas and keeping field notes. The girls acquired zero offset radar profiles over a 2-meter by 3-meter area of the ash bed known to contain the skeletons of a mother rhino and her calf.

This area had been partially excavated. After the skeletons were discovered they were then covered again with ash for protection and later excavation. The Scouts processed the data in the field and interpreted the hyperbolas as reflections from rhinoceros skeletons. They did a great job and we all had a lot of fun, even though it couldn't have been more than 114°F!

1999 GP Grads

B.S. Degree
Robert M. Black
Anthony Alexander Burgard
Bethany Lynn Burton
Abraham Michael Emond
Matthew Matson Haney
Michael Ryan Jones
Markus Mattias Lagmanson
Stefany Brook Lewis
Richard L. Parkes
Kin-Man Edmond Sze
Erin Lynn Wallin

Professional Degree
David S. Abbott
Erich Arai
Richard L. Parkes
Cheng Peng

M.S. and M.E. Degrees
Nazim Resmioglu Abdullayev
Jared Dale Abraham
James Jay Blaylock
Robert M. Fiore
Miguel Galarraga
Paul Edwin Murray
Kim C. Oshetski
Friedrich Roth
Amber Lynn Storch

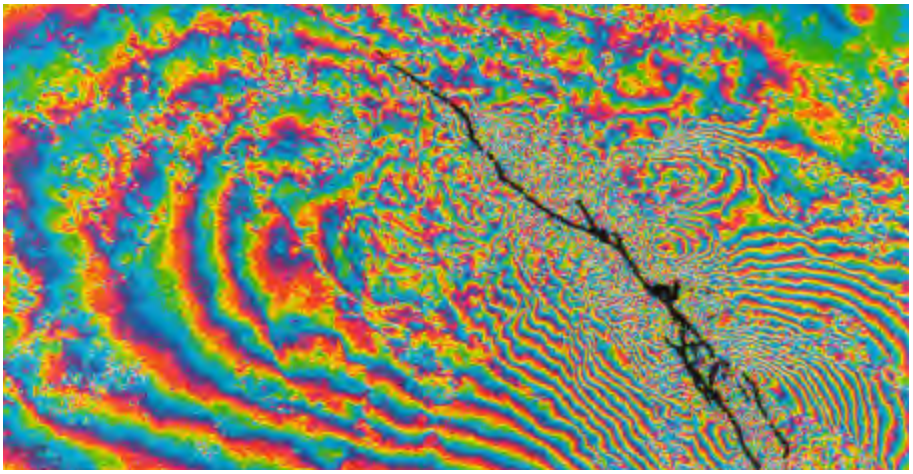
Ph.D. Degree
Birsen Canan
Walter Goedecke
Gilein J. Steensma

Graduate Student Attends SAR Workshop

by David Stillman

This past summer I worked with Professors Li, Olhoeft, and Young to develop a new course module in satellite remote sensing. We developed examples of satellite imagery for applications ranging from mineral exploration and monitoring volcanoes, to exploring other planets. These were incorporated into a course in the core undergraduate curriculum in which sophomores are first introduced to the field of geophysics. Several applications of satellite remote sensing in geophysics make use of radar.

As part of my work I had the opportunity to attend a NASA sponsored Synthetic Aperture Radar (SAR) workshop in Los Angeles. The goal of the workshop was to gather top experts in the SAR research world, to compose a proposal for NASA to fund a US civilian SAR program. Presently, the US scientific community must obtain current SAR images from the Europeans, Canadians, or Japanese. Unfortunately, the ordering/delivery process is a lengthy one (6 months on average). Another option is to scan old SAR images taken from shuttle missions flown in 1981, 1984, 1994 and 2000 for the desired image.



This is a portion of an InSAR image of the Lander's Earthquake, which occurred in California on June 28, 1992. Each fringe represents approximately 2.8 cm of vertical displacement caused by the earthquake.

Unlike visible and infrared satellites, a SAR satellite can see through moderately heavy vegetation, clouds, and at night. During the conference, we discussed the applications of SAR and interferometric SAR (InSAR). These applications include the monitoring of volcanoes, earthquake topography changes, the cryosphere, natural disasters, the hydrologic cycle, subsidence, and biomass.

The 113 participants hailed from a variety of organizations including FEMA, JPL, USGS, LANL, LLNL, NASA centers, and universities. Roughly 15% were students.

David Stillman, who received his B.Sc. in geophysics from CSM in May 2000, is now pursuing his master's degree under Professor Gary Olhoeft.

2000 GP Grads

B.S. Degree
Jonathan James Bennett
Brian T. Clark
Jason Ethan Gumble
Todd Garrett Lapinski
Todd Matthew Meglich
Margo Michelle Ratcliff
David Brian Sinex
David Earle Stillman
Randall R. Thomas

Professional Degree
Scott A. Baker
Manuel Gonzalez-Fernandez
Geddy L. Moran
Shogo Narahara
Michael T. Poirier

M.S. Degree
Robert Bunge
Catalina Rene Acuna Godoy
Baoniu Han
Efrain Mendez Hernandez
Christopher Robinson

Ph.D. Degree
Robert J.L. Lorenzen

Environmental and Engineering Geophysics Society: New Chapter at 'Mines

Many people associate CSM's Department of Geophysics with the petroleum industry, because historically that sector has hired a large proportion of the department's graduates. However, environmental and engineering geophysics are also alive and well at Mines. In fact, interest in these areas of application is growing among our current students.

Two of our Distinguished Senior Scientists, Pieter Hoekstra and Adel Zohdy, served as General Chairman and Technical Program Chairman, respectively, of SAGEEP—the Symposium on the Application of Geophysics to Engineering and Environmental Problems—which is the annual meeting of the Environmental and Engineering Geophysics Society (EEGS). SAGEEP was held March 4-7 in Denver. Amy Walker, President of the Student Society of Geophysicists (SSG) also served on the technical program committee. Kristen Sneddon, a graduate student in geophysics, gave a technical presentation on her research. A large number of CSM students, both undergraduate and graduate, volunteered to work in various capacities at the meeting. Students also organized and staffed a CSM table at the meeting.

Leading up to SAGEEP, there was a ground swell of interest among the students to activate a CSM student chapter of EEGS. Geophysics graduate student Kate McKinley took the lead and invited Dr. Mike Powers, outgoing First Vice President of EEGS, to be the featured speaker at a kick-off luncheon on campus. Mike is a CSM alumnus and a research scientist at the USGS. He is currently teaching a section of sophomore EPICS (Engineering Practices Introductory Course Sequence) that is doing an archeological application of geophysics in nearby Douglas County. (Jim Oltmans, another geophysics alumnus, brought the Douglas County project to the attention of the department.)

There was a great turnout of students and faculty alike for the kickoff meeting of the new student chapter of EEGS.

EEGS outgoing vice president Mike Powers was guest speaker for the kickoff luncheon of the new student chapter, pictured here with CSM graduate student and event co-organizer Kate McKinley.

Some Things in Life ARE Free!

SU Seismic Unix (SU) is a self-contained software environment for seismic research and data processing that is compatible with all Unix and Unix-like operation systems. CWP Research Associate John Stockwell, SU co-developer and project manager, maintains the software and implements its many updates and improvements.

SU is freely distributed on the Internet at http://www.cwp.mines.edu/cwpcodes. There are currently 2200 installations of SU in 55 countries.

Samizdat Press

The Internet archive, Samizdat Press, offers a free collection of books and lecture notes that you may download. Samizdat was begun by John Scales at CSM and Martin Smith of New England Research as a vehicle for distributing technical documents of interest, at no cost to the user. Check out the list of Samizdat Press offerings at the web site: http://landau.mines.edu/~samizdat.

Heightening Students' Awareness of Geophysics

Both industry and government employers of geophysicists and geophysical engineers have recognized the gaping hole in their own internal demographics. But have they realized that the feedstock at the input side of the educational pipeline —the source of our geoscience and geo-engineering professionals of the future—looks increasingly diverse these days? It is becoming a richer and richer blend of young people from groups that have historically been under represented in geoscience and geo-engineering. How do we bridge the gap between our field and these important segments of our population?

The Colorado School of Mines began a Minority Engineering Program (MEP) in 1989. Today the program is flourishing under the direction of Judi Diaz Bonacquisti. However, for the most part, Hispanic, African American, Native American, and Native Pacific Islands students in MEP are choosing to major in traditional engineering disciplines like chemical, electrical and mechanical engineering. They have never heard of geophysics; in fact, they tend to be a bit intimidated by the name, and they certainly have no role models in geophysics or geophysical engineering. We are setting out to change that.

Recently, Armando Telles, Jr., a consulting geophysicist who spent 28 years with Mobil, made a presentation on campus to the Society of Hispanic Professional Engineers and Scientists and other students in the Minority Engineering Program at CSM, regarding his experiences as Mobil's Exploration Manager in Bolivia and Peru. This summer the Department will participate in MEP's SUMMET (Summer Minority Engineering Training) by presenting a module in geophysics. In the longer term, we plan to establish a mentoring program for minority students that emulates the successful model pioneered by Women in Geophysics.

Armando Telles, Jr., speaks to the Society of Hispanic Professional Engineers and Scientists and other students in the Minority Engineering Program at CSM.

For Prospective Students

The field of applied geophysics encompasses a broad spectrum of interesting activities. For example, geophysicists team up with geologists and geochemists to explore for natural resources, like minerals and hydrocarbons, in order to meet the increasing demands of the growing population on planet Earth. They work with geologists to study earthquakes and volcanoes in order to help mitigate the effects of these natural disasters on populated areas. Geophysical engineers and civil engineers investigate sites for major construction projects, both above and below ground, to insure the stability of large-scale structures. And geophysicists work with environmental scientists to help provide adequate supplies of uncontaminated groundwater. Geophysicists are an essential part of the teams that explore Mars and other planets.

The Department of Geophysics at Colorado School of Mines is known around the world for excellence in applied geophysics. Geophysics alumni from CSM can be found in key technical and management positions in industries and governments worldwide. Currently the demand for our geophysics graduates is very strong, and the outlook is for that demand to grow significantly in the coming years. If you would like more information about our undergraduate or graduate programs, please contact Professor Terry Young by email (tkyoung@mines.edu) or phone (303-273-3454) or check us out on the web at

http://www.geophysics.mines.edu.

— The field of geophysics is fascinating, challenging, and rewarding.

Geophysics Department Research Activity

CWP

Center for Wave Phenomena

Faculty: Ken Larner, Director; Norm Bleistein, Maarten de Hoop (MCS), Vladimir Grechka, John Scales, Roel Snieder, and Ilya Tsvankin.

Now in its 17th year, the Center for Wave Phenomena (CWP) continues its interdisciplinary program of coordinated and integrated research in inverse problems and problems of seismic data processing and interpretation. Its methods have applications to seismic exploration, mapping the seabed, ocean sound-speed profiling, nondestructive testing and evaluation, and other areas. Extensive use is made of analytical techniques, especially asymptotic methods and computational techniques. Methodology is developed through computer implementation, based on the philosophy that the ultimate test of an inverse method is its application to field or experimental data. CWP is supported by 29 domestic and foreign oil companies and exploration service companies.

Director of CWP Ken Larner (left), and former director and now University Professor Emeritus Norm Bleistein (right) celebrate in December 2000 with CWP doctoral graduate Lan Wang (Mathematical and Computer Sciences).

CENPET

Center for Petrophysics

Faculty: Max Peeters, Director; Mike Batzle, Steven Dec (Chemistry), Alfred Eustes (Petroleum), John Fanchi (Petroleum), Neil Hurley (Geology), Maarten de Hoop (MCS), Gary Olhoeft, and Brian Ashbury (Mining).

The Center for Petrophysics (CENPET) is currently supported by five companies and provides MSc projects for seven students. The thesis subjects include monitoring invasion of mud filtrate in horizontal boreholes with ground penetrating radar (GPR); simultaneous inversion of shallow reading wireline logs to improve porosity and permeability estimates; measuring fluid and lithology effects on acoustic wave propagation in a shock tube; and comparing the response of acoustic and resistivity imaging tools to structural and stratigraphic rock features.

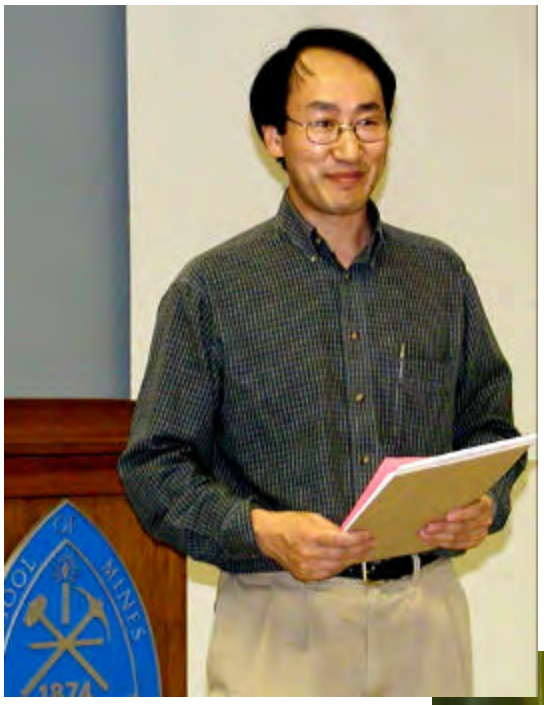
Petrophysical and formation evaluation courses are offered at the undergraduate and graduate levels. The undergraduate courses use web-based courses and computer log evaluation programs provided by sponsor companies. The graduate courses feature seminars by experts in logging, coring, and formation testing. The undergraduate course is supplemented by a Baker Atlas logging school in Odessa, Texas. Pictured below are CSM geophysics students and faculty attending the school in 2000.

GMRC

Gravity and Magnetics Research Consortium

Faculty: Yaoguo Li, Director; Misac Nabighian, Tom LaFehr, Tim Niebauer, Hengren Xia, Richard Hansen.

The Gravity and Magnetics Research Consortium (GMRC) is a newly formed facility for carrying out industry-sponsored research in gravity and magnetic methods. The consortium is working on a variety of problems ranging from theory, modeling, inversion, and interpretation to field applications. The goal is to develop new techniques that can solve practical exploration and production problems by utilizing the latest developments in geophysical inverse theory, applied mathematics, and modern instrumentation. The current research at GMRC is focused on the processing, inversion, and interpretation of gravity gradiometer data. Gravity gradiometer data measure the spatial gradients of the three components of the gravity field, and they have less platform-induced measurement errors and possess a higher resolving power than conventional gravity data.



Yaoguo Li, GMRC workshop facilitator.

Wavelet Transforms Topic of Web-based Workshop

The GMRC has been using wavelet transforms to tackle a variety of problems ranging from data processing to 3D inversion of gravity gradiometer data. In an effort to introduce this new method to the larger community of potential-field researchers and practicing geophysicists, the GMRC organized and presented on October 27, 2000 a web-based workshop on the application of wavelet transforms to potential-field problems.

The workshop was organized by Yaoguo Li and Misac Nabighian from GMRC in collaboration with Ed Biegert, Jerry Hensel, and Pat Millegan from the companies sponsoring the GMRC. The workshop featured seven invited speakers from the United States, France and Australia, three of which were from CSM. The workshop was presented live in Houston and broadcast simultaneously through the internet to eleven remote sites worldwide (four in the United States, four in Canada, as well as one each in Australia, Finland, and the United Kingdom). SEG President Sally Zinke was a participant at the CSM site. The web-based delivery of the workshop reached a much wider audience than would have been possible by conventional approaches.

Generous contributions from Dr. Tom LaFehr, the Rutt Bridges Family Foundation, the Society of Exploration Geophysicists, and Shell enabled students and members of the academic community to attend the workshop free of charge at various locations. This activity has prompted a great deal of interest in the use of wavelet transforms in gravity and magnetics and has enhanced the prestige of both GMRC and CSM.

Center for Rock Abuse

Geophysical Properties of Fluids and Rocks

Faculty: Mike Batzle, Director; G. Olhoeft, M. Peeters, J. Scales, R. Snieder (Geophysics); R. Christiansen, R. Graves, J. Fanchi (Petroleum Eng.); and M. Gardner (Geology).

For those of you acquainted with Professor Mike Batzle, you will not be surprised by the name he has chosen for his research center—The Center for Rock Abuse. Mike can usually be found down in the bowels of the Green Center where he has set up a laboratory to pursue fundamental research concerning the detection of fluids, especially hydrocarbons, in rocks.

Vanessa Mitchell prepares to crush rock.

Mike and his students are conducting experiments on rock samples and integrating their findings with seismic data acquired over sponsors' reservoirs. This research is a cooperative effort with HARC (the Houston Advanced Research Center) and it involves faculty participants from other CSM departments including Geology and Geological Engineering, Petroleum Engineering, and Mathematics and Computer Sciences.

RCP

Reservoir Characterization Project

Faculty: Tom Davis, Director; Bob Benson, Co-director; John Fanchi (Petroleum); Neil Hurley (Geology).

New Technology Tested During Weyburn Field Project

The Reservoir Characterization Project (RCP) specializes in the applications and interpretation of time-lapse, multicomponent (4-D, 3-C) seismic data, working with industry partners to develop a dynamic approach to reservoir characterization in order to enhance oil recovery.

At CSM, the project promotes interdisciplinary research and education for students. Over 60 students from the geophysics, geology and petroleum engineering departments have completed theses based on the research of RCP.

Currently ongoing, Phase VIII of the project comprises a $3.2 million seismic survey in the PanCanadian Weyburn Field in Saskatchewan with the goal to provide a detailed underground picture of a section of the oil-rich reservoir before and after it is reached by an injection of carbon dioxide.

The injected CO2 mixes with oil trapped in rock formations, causing the oil in the porous rock to be released and flow more easily.

To conduct this survey, Davis and his 30-member seismic crew from Solid State Geophysical Inc., Calgary, used a truck-mounted hydraulic vibrator to create shear waves in the ground, concentrating on a three-square-mile area. As these waves bounce off the subterranean formations and fractures where oil is trapped, they are recorded by 1,200 digital sensors, providing a high definition map of the underground area. Taking place during Fall 2000, the survey, using the shear wave technology developed by Davis at CSM, will help identify permeable pathways in the rock and therefore the movement of fluids within the reservoir can be predicted.

The technology and equipment used are new and were tested for the first time during this survey. "The goal is to test where fluids are going in the subsurface and see where they concentrate," explains Davis. A series of down-hole detectors also record any natural seismic activity in the reservoir that is induced by the CO2 injection.

Oil companies all over the world have their eye on the seismic technology being used in the Weyburn Field. The success of this survey could have an impact on the way companies approach the recovery of oil—by spending more time, money and effort getting an image of the reservoir before drilling and pumping. According to Davis, this type of advanced seismic imaging technology could have huge benefits, and perhaps lead to finding new sources of oil.

Davis is scheduled to conduct another survey of the same area during Spring 2001, after the injected CO2 makes its way into the test area.

The photograph and text are excerpts from a feature written by Kirsten Leatherdale of the Weyburn Review, *Saskatchewan.*

RCP Director Tom Davis poses with a member of his crew in front of one of three hydraulic vibrators used during the seismic shoot conducted in PanCanadian's Weyburn field. The vibrator is used to shake the ground in order to create waves that are recorded by 1,200 digital sensors. Davis and his crew employ a number of new technologies to get a detailed picture of a portion of PanCanadian's reservoir. These methods could change the way oil companies think about exploration.

Research in Avalanche Forecasting

Vicki Cowart wears many hats. She is State Geologist and Director of the Colorado Geological Survey (CGS). She is also a distinguished alumnus of the CSM Department of Geophysics, who serves as a mentor in the Women in Geophysics mentoring program (see article in this issue).

A year ago, Vicki brought to the attention of the Department the need for research to support avalanche forecasting in Colorado. The Colorado Avalanche Information Center (CAIC), a program of the CGS, funded an undergraduate research project in avalanche forecasting at CSM last summer.

Geophysics senior Amy Walker and junior Julia Oakes worked on the project under the supervision of Professor Terry Young. Expert input was provided by Knox Williams, Director of the CAIC, and Dale Atkins, an avalanche forecaster who has spearheaded computer applications at CAIC, including the development of their Internet site.

Knox and Dale provided over twenty years of weather data and associated records of avalanche occurrences at Berthoud Pass, Colorado. Amy and Julia analyzed these data to determine which variables were most strongly correlated to the occurrence of avalanches in that area, and they developed a forecasting model based on the nearest-neighbor algorithm that is commonly used in Switzerland and other avalanche-prone areas. The CAIC is currently testing the algorithm at its center in Boulder.

Other undergraduates, including Michael Rumon, Jessica Semmler, Francis Williams, and Julie Campbell have continued working with Terry on avalanche research during the current academic year.

Professors Young (left) and Kaufman were recently sighted at the top of Loveland Pass, allegedly doing some fieldwork associated with avalanche research.

New Books Available

Check out these new books written by geophysics faculty members:

- Norm Bleistein, Jack K. Cohen and John W. Stockwell, Jr., *Mathematics of Multidimensional Seismic Imaging, Migration and Inversion*, 2000, Springer-Verlag, (http://www.cwp.mines.edu/mmsimi).
- A.A. Kaufman and P.A. Eaton, *The Theory of Inductive Prospecting*, Vol. 33 in series on Methods in Geochemistry and Geophysics, 2001, Elsevier.
- A.A. Kaufman and P. Hoekstra, *Electromagnetic Soundings*, Vol. 34 in series on Methods in Geochemistry and Geophysics, 2001, Elsevier.
- A.A. Kaufman and A.L. Levshin, *Elastic Wave Fields in Geophysics*, I, Vol. 32, in series on Methods in Geochemistry and Geophysics, 2000, Elsevier.
- Ilya Tsvankin, *Seismic Signatures and Analysis of Reflection Data in Anisotropic Media*, part of the series on Handbook of Geophysical Exploration, 2001, Elsevier (http://www.elsevier.com/locate/isbn/0-08-043649-8).

Soon to be published:

- Roel Snieder, *A Guided Tour of Mathematical Methods for the Physical Sciences*, 2001, Cambridge University Press (http://www.mines.edu/~rsnieder/Guided.html).

Denver Geophysical Society

Research Associate Professor Bob Benson is currently serving as president of the Denver Geophysical Society (DGS). Approximately 400 active DGS members gather for luncheon meetings on the second Thursday of every month at the Wynkoop Brewery in Denver. Among the objectives of the DGS is the promotion of fellowship and cooperation among persons involved in or interested in the science of geophysics. Learn more about the DGS and their activities on their web site at www.denvergeo.org.

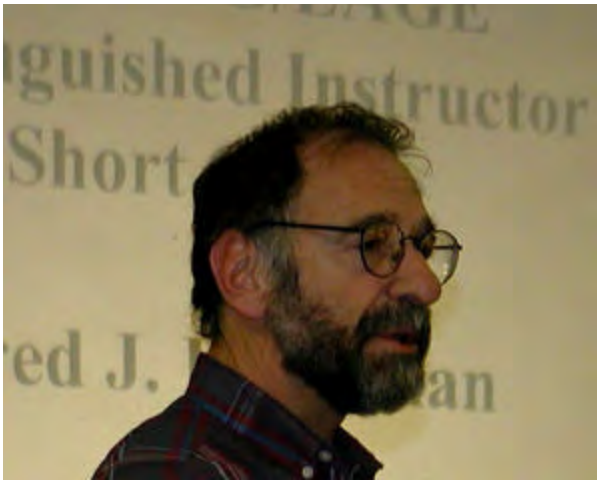
Bob Benson

Heiland Lecture Series Opens Window to the World

The Heiland Distinguished Lecture series continues to be a weekly feature in the life of the Department of Geophysics. This year, a generous donation from Schlumberger was used to provide travel expenses for some of the speakers invited from outside the Denver area.

One of the highlights of the series was an impromptu lecture given by Dr. Kaye Shedlock of the U.S. Geological Survey. Already serving the department as a member of the Visiting Committee and a mentor in the Women in Geophysics program, Kaye attended the Heiland Lecture immediately following the recent Seattle-area earthquake in March and presented the information she was assembling for USGS briefings. Kaye couldn't stop very long for the regular post-Heiland gathering in the Adams Room, since she was scheduled to be on an airplane to Washington, D.C. early the next morning to make official briefings on the quake.

Dr. Kaye Shedlock graciously accepted an invitation to give an impromptu Heiland presentation immediately following the recent Seattle-area earthquake.



Professor Ken Larner, himself a Distinguished Lecturer this year for the SPE, at a recent Heiland lecture advertises the upcoming presentation by another Distinguished Lecturer and alumnus, Fred J. Hilterman.

The tradition of post-Heiland social gatherings lives on. The gatherings are hosted by the Society of Geophysics Graduate Students (SGGS). Pictured here are (from left to right) graduate students Travis Wilson, Phil Brown, Ed Jenner, and Marty Terrell, along with Professor Tom Davis.

CSM Welcomes First Keck Professor

by Roel Snieder

In the Spring of 2000 I was appointed as the Keck Professor at the Colorado School of Mines. The goal of this chair is to strengthen interdisciplinary research and teaching in the geosciences at CSM. The formulation of this goal is timely, because researchers and teachers have become increasingly specialized, yet the problems we need to solve are often so complex that an interdisciplinary approach is needed.

Keck Professor Roel Snieder quickly became integrated into his new community by joining the volunteer firefighters. Here he stands with relief following a training exercise.

My background is suited for this task. After an education in theoretical physics, I briefly worked in geophysical fluid dynamics. Over the past ten years I have worked on various aspects of both global seismology and exploration seismology, putting much effort in my teaching to link the mathematics to topics that are of interest to students in the earth sciences. This has resulted in the book *A Guided Tour of Mathematical Methods for the Physical Sciences*.

Presently I am setting up a number of research projects. A common theme of these projects is "waves," with the projects chosen so that they form a natural interface with scientists in other departments at CSM. One project is aimed at making "coda wave interferometry" operational. When a medium strongly scatters waves in an incoherent fashion, we don't know how to make images of the medium on the basis of these data. In many applications, however, the primary interest is not to make an image of the medium, but to know whether or not the medium has changed. Because of the sensitivity of the multiple scattered waves to details of the medium, these waves can be used as a sensitive diagnostic to detect changes in media. One application is reservoir monitoring, but others include volcano monitoring, dam monitoring and non-destructive testing.

Parallel to the first project I am starting an interdisciplinary project aimed at a better understanding of liquefaction. A third research project is aimed at remote sensing of fault zones, which also has applications in reservoir problems, mining engineering, structural geology and hydrology.

It has been exciting to move to the Colorado School of Mines. Because of the close proximity of the Colorado School of Mines with the US Geological Survey and CU Boulder, the Colorado Front Range area has great potential to be a focal point of earth sciences.

Discovery Class

by Alison Malcolm

The Discovery Class is a class in which, simply stated, we learn to do research. We have chosen a research topic together as a class and are going through all the steps of researching this topic. This course is different than most in that the most important things we learn are not necessarily related to the topic we have chosen. We spend a significant amount of time discussing what we need to learn and what is the best way to learn it, which helps us to develop skills that will be useful in our future research.

Our chosen topic is "Why are fractals so common in nature?" We are currently looking into some of the basic properties of fractals and attempting to devise a theory as to why they appear in nature fairly commonly.

As part of the course, Dr. Snieder has invited expert researchers from both academia and industry to speak to us about how they do research. These people give us important advice, from a perspective different from that of Dr. Snieder, giving us a wider base to draw from in developing our own research strategies.

This course has been one of the most useful I have taken so far at CSM, because what we learn in the Discovery Class we will not learn from a book. The teamwork required in the course has also provided me the opportunity to become acquainted with other students from diverse backgrounds.

Alison is a first-year graduate student participating in Roel Snieder's course on discovery. The objective of the class is to answer the question: How do you discover? "Good research is not so much determined by your problem-solving skills, but by your ability to ask the right questions," says Snieder.

Sabbatical in France Yields Cooperative Learning Adventure for Scales

During the 1999-2000 Academic Year I was on sabbatical at the Laboratoire Ondes et Acoustique of the École Supérieure de Physique et de Chimie Industrielles de la Ville de Paris. During this stay I was a Professor of the French Academy of Sciences and holder of the Chair Elf/Academie des Science. I was one of only two foreigners so honored last year.

The Laboratory of Waves and Acoustics (LOA in French) is part of the École Supérieure de Physique et Chimie Industrielles (ESPCI). This is where the Curies discovered radium a hundred years ago. It's also the home of two current Nobel laureates. The ESPCI specializes in applied physics and chemistry. While there I had the opportunity to interact with many people in allied fields such as optics and medical imaging, who are working on the same sort of problems that interest me, but from completely different perspectives. For example, one of my interests is the use of diffusively scattered seismic waves to perform imaging. The same problem is at the forefront of a new area of medical imaging which seeks to use diffusively scattered photons to image inside the human body, which is sort of like trying to see a piece of broccoli inside a glass of milk. I shared an office at the LOA with people working on ultrasonic medical imaging and spent many hours at the blackboard bridging the nomenclature gap between what they do and what seismic imaging types do. This was extremely valuable for both.

The Scales family outside of the Louvre Museum in Paris: John, William, Emma, and Pamela.

I spent most of my time working on chaotic scattering and resonance; both topics I had been pursuing in my lab in Golden. These are great problems since they combine cutting edge physics with important applications in geophysics. In the case of resonance, the same device we developed to perform resonance ultrasonic characterization of rock samples can be used to probe fundamental questions of quantum chaos. Further, I think that the exploitation of multiply scattered waves (and other events we tend to discard as "noise") may be the next frontier in seismology. The notion of "chaotic scattering" is a hot topic in theoretical physics and seismologists are ideally suited both to verify theoretical predictions and to exploit these new theoretical tools to solve practical problems in imaging and inversion. Being able to pursue this work in a well-equipped laboratory surrounded by people with similar interests was a great opportunity.

I began two experimental projects in Paris which I am continuing in Golden. The first involves an attempt to see the breakdown of time-reversal invariance in a chaotic resonance system. By measuring thousands of resonant frequencies of a precisely machined mechanical oscillator in a vacuum chamber, I hope to see transition from time-reversal invariance to no time-reversal invariance as the pressure inside the chamber increases; coupling to the gas may appear as an apparent source of attenuation.

The second experiment involves the use of strongly multiply-scattered waves to make inferences about a scattering medium. It is important to realize that in many fields such as geophysics and optics, multiply scattered waves are regarded as noise. But in fact they are highly reproducible and represent a valuable new source of information. I believe that important advances in seismology and other fields can be made with this rich source of information.

Quite apart from the professional development I achieved, I will forever be grateful that my children had the opportunity to immerse themselves in a foreign culture, learn French in a French school, and have French friends. For this I thank the Colorado School of Mines, the French Academy of Sciences and the Elf Foundation.

Mentoring in Geophysics: What, Why and How?

by Barbra Maher

It is well documented that women drop out of scientific fields, including geophysics, all along the academic pipeline. For young women, it can be extremely challenging to reconcile the conflicts between family life and pursuit of a scientific career. This is where mentors and role models make an enormous difference. Mentors help the next generation of women in science reach their highest potential.

Barbra Maher

In Fall 1998, undergraduate and graduate women students gathered to discuss their needs and what the department could do to meet those needs. There were few, if any, women role models in the Geophysics Department and no female faculty members. The Women in Geophysics (WIG) Mentoring Program was developed for the women students at Colorado School of Mines to promote success in their academic careers and to prepare them for professional careers in geophysics. The mentoring program matches undergraduate and graduate women with professional women scientists working in the Denver area. All mentors and mentees assemble for group gatherings several times a year. In between, individual mentors meet one-on-one with their mentees to encourage the students and to answer their questions about education and career choices.

In recent years, the number of women students in the Department of Geophysics has continued to grow. Among undergraduate students, 40% of the seniors and 70% of the juniors are women. WIG makes a huge difference in the environment of the department by bringing in women professionals from the geophysics community to serve as mentors and role models for the students.

Volunteer mentor, Elizabeth Pottorff, and her mentee, CSM student Amy Walker, President of the undergraduate organization SSG, share a friendly moment at an event hosted by Women in Geophysics. Porttorff is President of the Denver Chapter of the Association for Women Geoscientists (AWG). She is employed as a hydrogeologist for the Colorado Department of Public Health and Environment.

Mentoring can provide the following:

- Information about careers and how the system works formally and informally,
- Basic career skills (assertiveness training, interview skills, conflict resolution),
- Connections to professional societies and individuals,
- Perspective on students' challenges and problems,
- Support and encouragement to build confidence, and
- Shared experience on and off the job.

We are always looking for more mentors, and encourage anyone interested to contact me about the Program. The main criterion for becoming a mentor is the desire to help someone else succeed by sharing thoughts and experiences. Visit our website at http://www.mines.edu/Academic/mentor/wgmp/ or send me an email at bschuess@mines.edu .

Barbra Maher, a Ph.D. candidate in geophysics, initiated the WIG Program and continues to serve as its Program Coordinator. WIG enjoys the support of the Women in Science, Engineering and Mathematics (WISEM) Program on campus, of which Barbra also serves as the program assistant. Funds to run the WIG program come from a combination of donations and departmental support.

The Department of Geophysics is currently revising its web site. What would you like to see on the web site? What would bring you back to the site again and again? Please email comments, content, pictures, or suggestions to Phil Brown, pjbrown@mines.edu.

VIP's

The Department of Geophysics Visiting Committee

The Board of Trustees of the Colorado School of Mines appoints a panel of experts to serve as an advisory board to the Department of Geophysics. Known as the Visiting Committee, this distinguished and diverse panel currently includes:

- **Dr. Colin T. Barnett**, Director of Exploration Technology, Newmont Gold
- **Mr. S. Rutt Bridges**, CEO, BigHorn Center for Public Policy
- **Dr. Fred J. Hilterman**, Vice President, Development, Geophysical Development Corporation
- **Mr. Harvy R. Klingensmith**, Sr. Vice President, International Exploration, El Paso Production
- **Dr. Rosemary J. Knight**, Professor, Stanford University
- **Dr. William Preeg**, Vice President and Director, Schlumberger Austin Product Center
- **Dr. Kaye Shedlock**, Research Geophysicist, U.S. Geological Survey
- **Dr. Yoram Shoham**, V.P. External Relations, Shell International Exploration and Production
- **Mr. Damir S. Skerl**, President, Skerl and Associates
- **Dr. M. Nafi Toksoz**, Professor, MIT
- **Mr. Bruce C. Wentner**, Geominex

Harvey R. Klingensmth

Rosemary J. Knight

William Preeg

Kaye Shedlock

Colin T. Barnett

The committee members visit the campus on a regular basis and interact with faculty, staff and students. They have contributed greatly to the ongoing success of the Department of Geophysics.

As we go to press, we are very saddened to learn of the death of Bruce Wentner on March 28.

Yoram Shoham

Damir S. Skerl

S. Rutt Bridges

Fred J. Hilterman

M. Nafi Toksoz

Bruce C. Wentner

Distinguished Senior Scientists Bring Expertise and Additional Flavor to the Department

The Department is honored by the participation in our program of these Distinguished Senior Scientists who each bring invaluable expertise from their varied lifetime careers. Left to right are Warren Hamilton (formerly with the USGS; interests in tectonic and petrologic evolution of th earth's crust and upper mantle), Adel Zohdy (USGS; electrical methods and groundwater geophysics), Tom Lafehr (LCT, Lacoste and Romberg; gravity and magnetics), Misac Nabighian (Newmont Mining Corporation; gravity, magnetic and electromagnetic fields), and Pieter Hoekstra (Blackhawk Geometrics; near surface geophysics).

Meet the Department Staff

Our department is fortunate to have a professional staff who keep us well organized. From left to right are Office Manager Sara Summers, Administrative Assistant Leslie Hayes, and RCP Administrative Assistant Barbara Brockman.

Right next door is the staff for the Center for Wave Phenomena (left to right) Publications Specialist Barbara McLenon, Program Assistant Michelle Szobody, and Administrative Assistant Lela Webber.

Invitations to All CSM Geophysics Alumni

You are invited . . . . Mark your calendar

1st ANNUAL

- Graduates and Alumni Honorees (with families and friends)
- Area alumni
- Alumni passing through Denver
- Faculty, staff, current students

GEOPHYSICS RECEPTION

MAY 4th, 2001

FOLLOWING THE GRADUATION CEREMONY

Friedhoff Hall

You are invited . . . . Mark your calendar

SEG San Antonio 2001

CSM Luncheon at SEG

Please join us

Tuesday, September 11, 2001

11:30-1:00 PM

SAN ANTONIO

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