The Center for Wave Phenomena is pleased to announce that two companies joined the Consortium Project on Seismic Inverse Methods for Complex Structures, bringing the total number of sponsors to 31. The new sponsors are: Cimarex Energy and Devon Energy. CWP thanks all consortium members for their ongoing support.
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CWP alumni sweep 2012 SEG Clarence J. Karcher Awards

Drs. Behura (2009 graduate), Dewangan (2004 graduate) and Malcolm (2005 graduate) will be presented with their awards during the 2012 SEG Annual Meeting in Las Vegas, Nevada, November 4-8.

The Karcher Award - given only by unanimous decision of the SEG Honors and Awards Committee as well as the SEG Executive Committee - recognizes significant contributions to the science and technology of exploration geophysics by a young scientist of outstanding abilities.

See Alison’s CWP alumni article on page 15.

(Alison Malcolm’s photo courtesy of Helen Hill)

Paul Sava elected to serve on EAGE Board

Paul Sava, CWP faculty and Colorado School of Mines associate professor of geophysics, was elected to serve on the European Association of Geoscientists and Engineers (EAGE) Board.

He will commence his two-year term in June 2012. Sava's responsibilities as the EAGE Education Officer will focus on directing and shaping EAGE’s educational activities, including but not limited to courses, lectures and student programs.

EAGE, founded in 1951, is a professional association of geoscientists and engineers with a worldwide membership of commercial and academic professionals. The multidisciplinary and international association consists of members who are professionals in, or studying, geophysics, petroleum exploration, geology, reservoir engineering, mining, and civil engineering.

SEG publishes third edition of Tsvankin’s book on anisotropy


The book is scheduled to become available in mid-October, prior to the SEG Annual Meeting in Las Vegas, Nevada on November 4-9, 2012. Tsvankin will conduct a book signing session on Tuesday, November 6, from 1:00-2:30 p.m. at the SEG Book Mart.


Save the date! 2013 CWP Project Review Meeting

The 2013 Review Meeting of the Consortium Project on Seismic Inverse Methods for Complex Structures will be held **May 13-16, 2013 in Golden, Colorado**. CWP will send meeting reminders and post additional information on our website, at [http://cwp.mines.edu](http://cwp.mines.edu). Please contact CWP program assistant Pam Kraus at pkraus@mines.edu or +1.303.384.2178 if you have any questions.
Congratulations to CWP graduates!

Congratulations to Mamoru Takanashi, Jeffrey Godwin, Conrad Newton, Ashley Fish and Clément Fleury!

Mamoru and Clément received their Doctorates in geophysics, while Jeff, Conrad and Ashley received their Master’s degrees in geophysics. Following graduation from CWP:

- Mamoru returned to the Japan Oil, Gas and Metals National Corporation (JOGMEC) in Chiba, Japan
- Jeff found employment at Transform Software in Denver
- Conrad has been working at MicroSeismic, Inc. in Denver
- Ashley found employment at Cimarex Energy, Inc. in Denver
- Clément will pursue a career opportunity in France

CWP high-performance computing
CWP computing resources growing at an accelerated pace

By Paul Sava

High-performance computing is broadly recognized as a prerequisite for modern seismic imaging and tomography for dense wide-azimuth seismic data. Several years ago, CWP identified computing as an essential skill for our graduate students and we committed to develop our computing infrastructure in order to sustain this growing need for large-scale computations.

This year we are, once again, expanding our presence on “Mio,” the Colorado School of Mines cluster administered by the Golden Energy Computing Organization (GECO). CWP is pleased to report that we are adding 360 compute cores to the 384 already available on Mio; thus, almost doubling our computing resources in one year. Each new compute node comes with dual 8-core Xeon processors, 64GB of RAM, 1TB of local storage and access to more than 100TB of disk storage available on a Panasas system, which was donated by BP a few years ago.

Cluster management software developed by former and current CWP students enables us to manage large-scale computing on Mio. Our software is available to all consortium sponsors, thus, facilitating effective technology transfer to the industry and an increased ability to engage in collaborative research.

Projects undertaken by current CWP students using the Mio infrastructure include: wavefield tomography (Tongning Yang, Francesco Perrone), waveform inversion (Esteban Díaz, Clément Fleury), wide-azimuth angle-domain imaging (Natalya Patrikeeva) and imaging with ground-penetrating radar (Detchai Ittharat).

CWP students and faculty look forward to sharing our research results with sponsors at future project review meetings.
Roel Snieder was invited as a guest presenter at the King Abdullah University of Science and Technology (KAUST) in Jeddah, Saudi Arabia, during January 23-25, 2012.

Prof. Snieder led a workshop called “Career Skills for Academics” for KAUST faculty, post-doctorate students and teaching assistants. His workshop focused on providing scientists with practical skills (for example, effective research habits and teaching skills) needed in a successful research career.

His workshop also included lessons and perspectives found in his book, The Art of Being a Scientist, which he co-authored with Colorado School of Mines Professor Emeritus Ken Larner.

By Roel Snieder

In June 2012, Clément Fleury and I attended the Summer School on Waves in Complex Media. The event, held in Heraklion, Greece, was attended by about 50 researchers from very different backgrounds, including: mathematics, geophysics, acoustics, and geodesy. Regardless of their respective fields, all participants were conducting research on waves in complex media.

On behalf of CWP, I discussed and presented on the seismic interferometry work that I carried out with graduate students and post-doctoral visitors.

... and Mathematical geophysics in Edinburgh

The biannual mathematical geophysics conference is organized by the International Union of Geodesy and Geophysics. This summer, the conference was held in Edinburgh, Scotland and brought together mathematically-oriented earth scientists from around the globe.

I was invited at this conference to give a presentation called “Autofocusing of Wave Fields.” I also convened a conference session titled “Solving geophysical problems.” The highlight of the meeting was renowned oceanographer Walter Munk, who, despite his advanced age of 94 years, gave a fabulous presentation on what we do not understand about water waves. His passion and enthusiasm were an inspiration for all who were in attendance.

Ilya Tsvankin featured in E&P Magazine

Ilya Tsvankin was featured in the February 2012 edition of Hart Energy’s E&P Magazine. The publication highlights Tsvankin and his Anisotropy-Team’s research on seismic fracture characterization. Tsvankin’s group is developing seismic inversion and fracture-detection methods based on realistic azimuthally anisotropic models of fractured formations.

The article, by E&P senior editor Rhonda Duey, discusses the role of geophysical methods in “unconventional” shale oil and gas plays. Mapping areas of high fracture density from seismic data helps identify “sweet spots” of increased production in many shale reservoirs.
15th International Workshop on Seismic Anisotropy (15IWSA)

Ilya Tsvankin and Ph.D. student Bharath Shekar were among the participants of the 15th International Workshop on Seismic Anisotropy (15IWSA) held in Bahrain from April 14-19, 2012. The 15IWSA continued a long tradition of biennial gatherings of anisotropists that dates back to the early 1980s. The workshop was organized by CWP alumnus Abdulfattah Al-Dajani of Saudi Aramco and his colleagues from the Dhahran Geoscience Society. It was the first IWSA in the Middle East, and geophysicists from that region were well represented among the 75 attendees. Despite the political unrest in Bahrain, the workshop went smoothly with no logistical problems. The wide range of technical presentations reflected a rapid transition of anisotropy-based methodologies into the mainstream of seismic exploration and reservoir monitoring.

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

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

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

Tsvankin teaches seismic anisotropy in South Korea

On July 24-25, Ilya Tsvankin was invited to teach a short course on seismic anisotropy at the Korea Institute of Geoscience and Mineral Resources (KIGAM) located in Daejeon, South Korea.

KIGAM is a leading Korean research institution that offers a broad earth sciences program including oil and gas exploration, mineral resources, geo-environment, groundwater, and CO₂ sequestration. The course was organized by the International School for Geoscience Resources at KIGAM and attended by 35 geophysicists and graduate students from several Korean universities and petroleum companies.

Participants included former CWP post-doctoral fellow SeongHyung Jang, who hosted Tsvankin at KIGAM. Jang says that anisotropy is not a familiar topic yet for most Korean seismologists, and he expects the course to help jump-start anisotropy research in his country.
CWP Research

Unfaulting and unfolding 3D seismic images

By Simon Luo

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

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

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

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

Simon joined CWP in August 2009 and works with Prof. Dave Hale. His current research is focused on automatic seismic image flattening and image unfaulting, which is useful for interpretation of geologic features and geologic deformation, as well as interpolation of subsurface properties. In summer 2011, he interned with Transform Software and Services. In summer 2012, he interned with Chevron Energy Technology Co.
Full-waveform inversion (FWI) is the name used for those inversion techniques that recover the model parameters (seismic propagation velocities, impedances, etc.) by matching the recorded seismic data to synthetic generated seismograms. FWI is able to reconstruct high-resolution models but requires accurate long-wavelength initial models to correctly reconstruct the kinematics of the wavefield in the medium. Migration velocity analysis (MVA) uses kinematics errors measured from the migrated images and aims at reconstructing the long-wavelength component of the model and thus supplies the necessary initial model for FWI.

Under the guidance of my advisor Paul Sava and with the support of Eni E&P and Nicola Bienati, I developed a new measure of velocity error based on the relative displacement between migrated images obtained from nearby shots and the direction of the structural features (the structural dip) estimated directly in the image domain. In Figures a and b, the white arrows indicate the dip estimated from the image and the black arrows the relative displacement between single-shot migrated images of a horizontal reflector. The dip and displacement vectors are mutually orthogonal when the velocity model is correct (Figure a), otherwise the angle between them indicates a velocity error (Figure b).

I used this observation to formulate an inversion problem based on penalized local correlations that measure the relative shift between migrated images. The relative shifts are considered as vectors and weighted by the distance normal to the reflectors: the bigger the shift, the higher the velocity error.

This approach based on penalized local correlations and nearby experiments allows us to compute corrections for the initial model using a very limited number of migrated images. Figure c and d show a real data example. After inversion, Figure d, we improve the focusing of the reflectors which indicate the higher accuracy of the velocity model.

Francesco joined CWP in August 2008 and works on his research with Prof. Paul Sava. At CWP, he worked on shot-encoding for fast wave-equation depth migration and his current interests are in numerical modeling and migration velocity analysis. During the summers of 2009, 2010 and 2012, he worked in Milan at Eni S.p.A. Francesco enjoys playing and listening to classical music, swimming and reading novels.
CWP Research

Wavefield reconstruction and focusing in an unknown medium

By Filippo Broggini

Geophysicists have used seismic interferometry (SI) to create a virtual source inside a medium, assuming a receiver is present at the position of the virtual source. In collaboration with my advisor, Prof. Roel Snieder, and Prof. Kees Wapenaar (TU Delft), I work on an iterative method that creates a virtual source inside a medium from reflection data measured at the surface (after surface-related multiple removal and deconvolution for the source wavelet), without needing a receiver inside the medium, hence, presenting an advantage over SI. In addition to the reflection data, an estimate of the direct arrivals between the virtual source location (black dot in Figure 1a) and the acquisition surface (at z=0) is required. These arrivals are a key element of the method because they specify the location of the virtual source in the subsurface and can be computed using a macro model (Figure 1b).

The figures show the results for a configuration with a syncline reflector, whose velocity is shown in Figure 1a. The density profile (not shown) has a similar behavior. The proposed method uses the upgoing reflected wavefield and a combination of time reversal and time windowing to construct the next iteration of the downgoing incident field. The reconstructed response shown in Figure 2a looks almost identical to the directly modeled response shown in Figure 2b. This scheme implicitly reconstructs the incident field that focuses the wavefield in time and space at the virtual source location. Figure 3 displays four snapshots in time.

Panel c shows that the wavefield collapsed to a focus at the location indicated by the black dot in Figure 1a. The complex wavefield propagating inside the syncline (panels a, b, and d) annihilates at the focusing time as shown in panel c.

Figure 1: a) Velocity model and b) macro model

Figure 2: a) Reconstructed wavefield and b) directly-modeled wavefield

Figure 3: Time snapshots extracted from the propagating wavefield; VS denotes the virtual source location

Filippo joined CWP in August 2008 and works with Prof. Roel Snieder. During the summers of 2010 and 2011, he interned with Schlumberger Cambridge Research in the United Kingdom. From August to October 2012, he is a visiting scholar at the Delft University of Technology in The Netherlands. Filippo is convinced that Afterhours is the greatest band in the world. Period.
Application of TTI tomography to BP synthetic data

By Xiaoxiang Wang

Accurate depth imaging for complex geologic environments (including subsalt plays and fold-and-thrust belts) requires heterogeneous anisotropic velocity models typically obtained by reflection tomography in the migrated domain. We have developed a 2D P-wave tomographic algorithm for heterogeneous transversely isotropic media with a tilted symmetry axis (TTI) which operates with reflection and VSP (vertical seismic profiling) data.

P-wave kinematics in TTI media is controlled by the velocity $V_{P0}$ in the symmetry-axis direction, anisotropy parameters $\varepsilon$ and $\delta$, and the orientation of the symmetry axis. To estimate the parameters $V_{P0}$, $\varepsilon$, and $\delta$ defined on rectangular grids (the symmetry axis is set orthogonal to the imaged reflectors), reflection data are inverted jointly with walkaway VSP traveltimes. Each iteration of the tomographic algorithm aims to simultaneously remove the residual moveout in common-image gathers produced by prestack Kirchhoff depth migration and minimize the VSP traveltime misfit. Also, we employ structure-guided regularization that imposes geologic constraints on the model and ensures more stable inversion.

The method was successfully tested on two sections of the TTI model produced by BP; one includes a salt dome (Figures 1, 2) and the other an anticline (not shown here). A purely isotropic velocity field, obtained from check-shot traveltimes and extrapolated along the horizons, served as the initial model. With sufficient constraints from reflection and VSP data, the TTI parameters in the shallow part (above 5 km) of the salt-dome section are well-resolved (Figure 1).

The errors in the parameters $\varepsilon$ and $\delta$ increase with depth because of the small offset-to-depth ratio and reduced coverage of VSP rays. Still, the inverted model practically removes both the residual moveout in CIGs and the VSP traveltime misfit. Except for the steep flanks of the salt body, which could not be properly imaged using our ray-based method, reflectors produced with the TTI model from Figure 1 are coherent and well positioned (Figure 2).
Summer 2012 industry internships
CWP students gain valuable industry experience and expand their research horizons

Farhad BAZARGANI
Shell International E&P in New Orleans, Louisiana
Focus area/topics: OBS azimuthal illumination study

Andrew MUÑOZ
Newfield Exploration in Denver, Colorado
Focus area/topics: AVO inversion, elastic impedance, prospect detection, well planning, seismic processing

Nishant KAMATH
Shell International E&P in Houston, Texas
Focus area/topics: Full waveform inversion of acoustic data to estimate low-wavenumber components of velocity and anisotropy parameter $\eta$

Francesco PERRONE
Eni S.p.A. in San Donato Milanese, Italy
Focus area/topics: Migration velocity analysis; waveform inversion in the image domain; application to real data

Chinaemerem KANU
Microseismic, Inc. in Houston, Texas
Focus area/topics: Microseismic location and detection

Bharath SHEKAR
ConocoPhillips in Houston, Texas
Focus area/topics: Multicomponent processing and inversion

Simon LUO
Chevron Energy Technology Co. in San Ramon, California
Focus area/topics: Seismic image processing, dip estimation, horizon tracking, image flattening

Tongning YANG
BP America, Imaging Research & Development in Houston, Texas
Focus area/topics: Robust initial model building for full-waveform inversion using wave-equation tomography

2012 CSM Geophysics Field Camp
CWP faculty and students get their hands dirty

By Ashley Fish

If hiking kilometers up a forested mountainous trail while jug hustling weren't insane enough, try hiking to a remote location and digging a hole meters deep for the CSMAT equipment. At elevation... With bears... Now, imagine being fortunate enough to be placed in these situations with sixty new faces from all around the world, with backgrounds ranging from material science to electrical engineering, to mathematics and geophysics.

Further yet, imagine that such geophysics-related mountaineering and rock climbing adventures would breed lifelong friendship and memories worthy of story time with your future grandchildren. This was the experience of Geophysical Field Session 2012, an experience to be remembered.

From May to June, Colorado School of Mines Geophysics Department students teamed up with students from Imperial College, London, UK and RMIT, Melbourne, Australia, to participate in the field session. 85 students, faculty, staff and industry partners retrieved data and processed them to characterize geothermal energy resources in Pagosa Springs, Colorado.

During the first half of the field session, students were in the field designing and implementing strategic fact-finding surveys. Geophysical methods ranged from DC Resistivity and Electromagnetics to GPR, Deep Seismic, and beyond. During the second half of field session, the students returned to Golden to process and integrate all of the data sets. Each data set gave a unique insight into the geothermal system of Pagosa Springs.

For a detailed account of the geothermal system and embarrassing photos of the field-campers, please visit the CSM Geophysics Field Camp website, at:

http://geophysics.mines.edu/GEO-Field-Camp
Seismic Un*x - 27 years and counting!

Thousands of SU users can’t be wrong

By John Stockwell

In the early 1980s, a geophysicist named Einar Kjartannson began writing a collection of seismic data manipulation codes in the C programming language - a kind of revolutionary idea at the time when everybody was working in Fortran. This collection of software later became the SY package, which was used in the mid 1980s by the students and faculty of the Stanford Exploration Project (SEP) at Stanford University.

In 1986, Stanford graduate Dr. Shuki Ronen brought SY to the Colorado School of Mines when he was serving a temporary faculty appointment with the Center for Wave Phenomena (CWP). In 1987, after a visit with Joe Higgenbotham of Texaco, CWP co-founder Jack Cohen decided to create a "seismic processing line that everybody could use" based on SY. That package was renamed SU. At that time, "everybody" consisted of expert users.

I would mention that the idea of creating software to be released free of charge, as full source code, was quite revolutionary at the time. Typically geophysicists commercialize software. One of my colleagues heard about our project, and suggested, "Time to start a company." Fortunately we did not heed his advice.

My involvement with SU began about 1988, when I was a volunteer worker for CWP. I later was hired as a research assistant to manage CWP's Masscomp 5700 Unix mini computer. By 1992, I was promoted to Research Associate, and was working extensively with Jack on SU. We had issued a number SU releases both on floppy drives. One day, Jack asked me to port SU from a our Masscomp system to the School's Gould (Unix) computer. I was able to do this with about a day's work - quite a feat, considering that previous versions had taken up to a week to port. I resolved to make the installation process easier.

By 1991, the Colorado School of Mines had a direct Internet connection, permitting the distribution of our codes from an anonymous ftp site. There were still fewer than 20 users known to us, though we did not really keep systematic usage statistics at that time. On 16 September 1992, we issued our first "official" Internet release (Release 18) using a much improved installation procedure.

By this time I had simplified the installation process of SU sufficiently that it was possible to install the package with a minimal amount of modifications. I also imbedded a script in the install process that would send me an e-mail message so that I could track users. Capturing the e-mail addresses of those users provided a ready supply of direct mail targets for messages regarding future releases.

But how do you reach more geophysicists to tell them about your project? In 1994, I attended the SEG Annual Meeting. My approach was to wear a distinctive hat (a grey fedora) and walk the convention floor, passing out pamphlets to inform people of our package. I repeated this mode of marketing for about 10 years, and each time the number of new installations would always increase. The magic of open source software projects is that you really are not working alone on your code. There are always suggestions, bug reports, bug fixes, code extensions, and questions that expand the capabilities of the package. Even this early installation procedure could not have been done without feedback from a number of users.

In 1994 Jack and I received the University to Industry award from the Technology Transfer Society for our work with SU, largely because nobody in exploration geophysics was doing what we were doing.

Jack Cohen passed away in 1996. This was a great shock and sadness to faculty and students of CWP. This happened in the middle of the Fall Semester. I was asked to take over Jack’s complex variables class, which I did. It was the most difficult and challenging teaching experience that I had before or since. I assumed the role principal investigator of the SU project and I have been serving in that role since 1996. SU had been installed in about 25 countries at that time. Through a combination of codes written by CWP members, and a much larger participation by the global community of SU users, the package expanded by about a factor of 3 in terms of codes since 1996.

In early 2001, the Center for Wave Phenomena, Einar Kjartannson, Shuki Ronen, Jack K. Cohen (posthumously), and I received a Special Commendation for our work with SU from the Society of Exploration Geophysicists (SEG).

Owing to suggestions that I received at the Annual Meeting of the SEG, I started a listserv group for SU users in December of 2001. The membership of that listserv group initially was 200-300 regular users. Owing to the importance of open source projects, such as SU, the European Association of Geoscientists and Engineers (EAGE) held a workshop for Open Source Software in E&P at its 2006 Annual Meeting in Vienna.

In the subsequent six years, the SU project has continued, expanding the user base to installations in more than 81 countries and territories. The listserv group has 1200-1300 regular users. In addition to CWP Consortium support, the Gas Research Institute and the Society of Exploration Geophysicists have funded the SU project. In the period from 1995 through 2005, the SU project brought in approximately $300,000 from these additional sources in the form of grants to CWP.

John Stockwell is the CWP research associate. He is the principal investigator of the Seismic Un*x (SU) project. John was co-recipient with Jack K. Cohen of the 1994 University to Industry Award from the Technology Transfer Society, and was co-recipient of a Special Commendation of Award from the SEG. He is a Special Editor of Geophysics, the Wiki Administrator of the new SEG Wiki and sits on SEG’s Online Content board and the Historic Preservation Committee.
Welcome! New CWP students
Six new students join us in Fall 2012

Stefan COMPTON
Home country: USA
Degree Program: M.Sc., Geophysics
Advisor: Prof. Dave Hale

Yuting DUAN
Home country: China
Degree Program: Ph.D., Geophysics
Advisor: Prof. Paul Sava

Jason JENNINGS
Home country: USA
Degree Program: M.Sc., Geophysics
Advisor: Prof. Paul Sava

Vladimir LI
Home country: Russia
Degree Program: Ph.D., Geophysics
Advisor: Prof. Ilya Tsvenkin

Natalya PATRIKEEVA
Home country: Russia
Degree Program: M.Sc., Geophysics
Co-advisors: Profs. Paul Sava and Ilya Tsvenkin

Xinming WU
Home country: China
Degree Program: Ph.D., Geophysics
Advisor: Prof. Dave Hale

CWP athletes compete in CSM swim and intramural track meets
CWPers respected for more than just their brains

Dave Hale, CWP’s fearless leader, students Andrew Muñoz and Francesco Perrone, along with fellow CSM Geophysics student Guillaume Barnier teamed up to form “1500m/s,” a.k.a. the Geophysics swim team. The swimming and splashing geophysicists competed in the Colorado School of Mines intramural swim meet on December 4, 2011 and did us all proud by placing fourth overall. Congratulations and well done, gentlemen!

Also, both men and women of CWP and the Geophysics Department laced up their running shoes and joined forces to form the “343 m/s” track team. We competed in many events the intramural track meet on April 23, 2012. Our women’s 4x100 relay team ran away with first place and won the highly coveted intramural T-shirts, while the other relay teams came in close second and third places. The runners in the individual events achieved many triumphs, and placed in the top of the field. Our team looks to regroup next year for another competitive track meet. Congratulations to all participants and thank you to everyone who came out to support us!
Geoscientists Without Borders

Using geophysics for a better world

By Roel Snieder

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

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

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

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

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

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

*Roel Snieder is the W. M. Keck Foundation Distinguished Chair in Basic Exploration Science at the Colorado School of Mines. He served as CWP director from June 2008 to May 2011. He was named Chief of Genesee Fire Rescue in Summer 2012. Dr. Snieder has a passion for good jokes and peanut butter sandwiches.*
Since its inception, CWP has been nurturing many graduate students majoring in geophysics, computer science and mathematics. Our alumni have gone on to do some amazing things in their careers across diverse fields for various employers around the globe. Below, four CWP alumni share their perspectives.

**By Thomas Cullison, M.Sc.**

Since my graduation in May 2011, I joined the Hess Corporation in Houston, Texas. Over the past year I worked on developing migration algorithms, quantitative seismic applications, and GPU-based codes. In the future, I might do research and software development for gravity, electromagnetics and other geophysical data.

My time and research at CWP helped me to become more engaged with the industry. I was able to interact with a wide range of industry and academic experts. I also received great feedback from students, faculty work on projects you find fascinating. For those interested in wave propagation and seismic imaging, CWP is a great place to learn to work and interact with an international group of exceptional students and faculty. I truly believe my time spent there helped accelerate my career.

My advice to students considering graduate school is to find a program in which you fit, where the students and faculty work on projects you find fascinating. For those interested in wave propagation and seismic imaging, CWP is a great place to learn to work and interact with an international group of exceptional students and faculty as well as a great way to open doors to a variety of interesting careers.

**By Alison Malcolm, Ph.D.**

I am currently an assistant professor of geophysics at MIT, a post I have held since 2008. As most professors do, I split my time between teaching, advising students, research, and institute/community service.

I teach courses from introductory geophysics courses to specialized seismic imaging graduate seminars and advise students from incoming freshmen to PhD students. As a researcher, I have the opportunity to travel the world to interact with top researchers in mathematics and seismology.

At CWP, I learned how top quality research is done by interacting with both my fellow students and the CWP faculty. During my time there, I became interested in multiply-scattered waves and in how waves interact with complicated structures in the Earth’s subsurface from both a mathematical and geoscience perspective. After I graduated from CWP, I spent two and a half years as a post-doc during which my interests broadened to include more general nonlinear wave phenomena and imaging outside of Earth sciences. The research group that I lead at MIT focuses on these things; we work on exploiting small signals that are typically discarded as noise to learn about properties of the Earth.

My advice to students considering graduate school is to find a program in which you fit, where the students and faculty work on projects you find fascinating. For those interested in wave propagation and seismic imaging, CWP is a great place to learn to work and interact with an international group of exceptional students and faculty as well as a great way to open doors to a variety of interesting careers.

**By Chris Engelsma, M.Sc.**

My current role focuses on creating solutions to challenging interpretation problems for business units from around the world. While the requests are all different, each deliverable needs to be timely and accurate. This requires me to look at any given request using multiple hats: I’m neither "The Geoscientist", nor am I "The Computer Scientist", but I’m both – such a dual role once seen as a paradox has become a requirement.

My time spent at CWP helped me augment my technical skills; I feel this goes without saying. CWP is full of extremely brilliant minds. The aspects that I feel go unspoken are the development of professional skills. The writing and presentation skills that I learned at CWP have already helped my career tremendously. The ability to effectively communicate your ideas can truly make or break a project, and this is something I graciously thank my advisor, Prof. Dave Hale for teaching me.

I feel fortunate to have earned my degree from CWP and for the experience of working with passionate faculty members and students. I truly believe my time spent there helped accelerate my career.

**By Thomas Cullison, M.Sc.**

Thomas graduated from CWP in 2011. He primarily works on research and software development for seismic data processing at Hess Corporation in Houston, Texas.

**By Chris Engelsma, M.Sc.**

Chris graduated from CWP in 2011. He is currently employed as a Research Geophysicist for the Seismic Interpretation and Earth Modeling R&D group at Chevron Energy Corporation in Houston, Texas.

**By Alison Malcolm, Ph.D.**

Alison graduated from CWP in 2005. She is an assistant professor of geophysics at the Massachusetts Institute of Technology in Cambridge, Massachusetts.
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CWP alumni: Then and now (continued)

By Jia Yan, Ph.D.

I am currently working in the ExxonMobil Upstream Research Company on the Signal Enhancement and Imaging Team. My daily job relies strongly on what I learned while I pursued my Ph.D. at the Center for Wave Phenomena. Even now, two years following my graduation, I browse through the CWP website and attend CWP’s annual Consortium Project Review meetings to learn about CWP’s new research.

In my opinion, CWP is an ideal place to work on a Ph.D. for exploration geophysics. CWP has one of the strongest exploration programs in that it accommodates people with all different research interests. The faculty members have diversified specialties and field interests, while graduate students may choose to work on comprehensive projects and thesis topics without limiting themselves to one small research area. As a result, CWP graduates usually possess a broad research horizon. A doctorate degree from CWP well prepares one for future work either in academia or the industry. I, for one, had the privilege to work with Prof. Ilya Tsvankin and Prof. Paul Sava, from both of whom I gained very different perspectives to geophysics.

One other great benefit CWP offers is its strong connection with industry, and faculty invites industry speakers to give presentations regularly. This is a great resource that students should take advantage of, as the speakers often bring with them the industry’s state-of-the art research and technology. One can obtain insights and find research topics just by having discussions with them.

Other than studying, CWP is located in the great State of Colorado, one of the most beautiful states in the United States. One can do all kinds of interesting things there: if you are an outdoor person, you have all the alpine mountains within an hour’s drive; if you are a city person, you have Denver and Boulder nearby. No matter who you are, you will never tire of studying at CWP.

Jia graduated from CWP in 2009. She currently works at the ExxonMobil Upstream Research Company in Houston, Texas.

CWP Visitor reflections

“How do people in Colorado get any work done?”

By Michael Behm

I joined CWP in August 2011 to work on a two-year project on seismic interferometry with Prof. Roel Snieder. My background is related to crustal-scale active seismsics and near-surface studies with ground penetrating radar, so my project at CWP is an excellent opportunity to get introduced to a new scientific field.

I was impressed right from the beginning by the broad scope of Geophysics at Colorado School of Mines, and by the large number of highly competent staff and students. ExxonMobil funds my project, so I visit Houston from time to time, which provides interesting insights into the different world of industry. My work focuses on extraction of local sub-surface information from continuous seismic recordings. It is an interesting and challenging task, since the applied methods are more commonly used in global seismology. I was able to present my results at the 2012 CWP Project Review Meeting in Breckenridge, while a first paper is being submitted to a journal.

Apart from CSM, the proximity of the Rocky Mountains is a very big plus to living in Colorado. I like to be surrounded by mountains, and I’m also into different kinds of outdoor activities. Being the geographically highest state in the United States, Colorado makes it sometimes hard to focus on the work. The title of this article was an actual question from a similar-minded visitor whom I met while rock climbing. It is quite easy to find people with whom to share passions for the outdoors – climbing, biking, hiking, camping, fishing, kayaking, ski mountaineering or caving. A personal highlight for me was skiing down from Torreys Peak, one of Colorado’s most beautiful “14ers” (summits with more than 14,000 feet of elevation).

Most important, I was happy to make good acquaintances with people from outside and inside CWP. The ethnic and cultural diversity here is mind-opening in many aspects and eases social life for newcomers and veterans alike. I am very glad to do a second year here, and I thank everyone at CWP for making my stay so splendid!