

DEPARTMENT OF EARTH AND PLANETARY SCIENCE

Alumni Update • 2009 - 2010



UNIVERSITY OF CALIFORNIA, BERKELEY

photo by Roland Bürgmann



Left to right: George Brimhall and staff Micaelee Ellsnythe, Judith Coyote and Catherine Pauling enjoying the sun in front of McCone in a setting that some alums will remember as a parking lot.

photo by Roland Bürgmann



Left to right: Bill Dietrich, Rudy Wenk and Barbara Romanowicz cutting their cakes at a faculty party last fall to celebrate their honors (see p. 2).

photo by Richard Allen



Henry Allen, one day old, born April 26, 2010. Richard and Kasia Allen's new son clearly is a future seismologist like his father.



photo by Margie Winn

Phil Behrman (2nd from left), whose gift established the Graduate Student Field Support Fund, flanked by Rudy Wenk (left to right) Richard Allen, and Chair Roland Bürgmann.

photo by Margie Winn



Chancellor Robert Birgeneau congratulating Walter Alvarez on his 2010 Faculty Research Lecture.

Editors: Doris Sloan, Micaelee Ellsnythe,
Judith Coyote
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Cover Photo: Nearly every year since 1982 Professor Bill Dietrich has taken his geomorphology class to Marin County to investigate the mechanisms of landsliding and soil transport at a site first described by Berkeley graduate Andre Lehre (who worked with Professor Clyde Wahrhaftig) and subsequently studied by Berkeley graduates Steve Reneau, Cathy Wilson, and Dave Montgomery. (Note to EPS 117 alumni: look how the baccharis and trees are slowly taking over the site!).

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THE STATE OF THE DEPARTMENT, 2009-2010

Dear Alumni and Friends,

I am pleased to be reporting back to you about the latest at the Department of Earth and Planetary Science. The 2009-2010 academic year seemed to have gone by fast, and it was a busy and exciting year for all of us. Looking back, there is much to be proud of, thanks to the accomplishments of our students, postdocs, staff, and faculty.

EPS continues to be recognized as a top department in the country. Just in time for this update, we received the results of the most comprehensive evaluation of Ph.D. programs in the country to date by the National Research Council. No matter how one looks at the results, EPS is one of the very best earth science programs in the country (<http://graduate-school.phds.org/rankings/earth-sciences/program/ranking/berkeley/5165>). On campus, Walter Alvarez was honored as the 2010 Faculty Research Lecturer, which is a top campus honor that recognizes Berkeley faculty members distinguished for scholarly research in their field of study. Recently, we also learned that Walter is the recipient of the first Daniel E. and Marian E. Koshland Distinguished Chair in Teaching and Research. This endowed Chair recognizes not only Walter's long-time research accomplishments, but also his exploration in Big History, from the Big Bang to the present, which he does through his teaching and current research work. Also during this last year, Raymond Jeanloz was elected a Fellow of the American Physical Society for contributions to the development of sound public policy for nuclear weapons management and non-proliferation. Clearly his activities and interests go well beyond high-pressure mineral physics. At the 2009 Annual Fall Meeting of the American Geophysical Union in San Francisco, Barbara Romanowicz received the 2009 Inge Lehmann Medal and Bill Dietrich was honored with the 2009 Robert E. Horton Medal of the society - both medals represent the top honors in their respective fields. Also, Emeritus Professor Rudy Wenk received the Abraham-Gottlob-Werner-Medaille in Silver for 2010, the highest honor of the German Mineralogical Society, and Doris Sloan was inducted as Honorary Fellow of the California Academy of Sciences. Finally, we are thrilled to welcome a new faculty member at EPS. Climate Scientist David Romps, currently a Research Associate at Harvard, will be joining us January 1, 2011.

Of course, we are especially proud of our students and postdocs, both during their time here at Cal and as they continue to develop their careers in subsequent years. Our undergraduate major continues to grow, and we are able to offer a broad major with specializations in a wide range of Earth Science topics. Our latest addition, the Planetary Science track is off and running, with Burkhard Militzer serving as our first undergraduate advisor.

As we highlight in some of the following pages, the student fellowships made possible by generous donations provide crucial support for our undergraduate and graduate students, particularly as the institutional funding for field courses and fieldwork has been diminishing. State funding to UC Berkeley has plummeted in recent years and today comprises only 21% of our total budget, so donations from EPS alumni and friends are ever more important to our continued success; we thank all EPS donors for your support and invite those of you who have not given to consider a donation to the department in an area of interest to you. Please contact me if you would like to discuss this.

Many of our undergraduates participate in summer field camp with support from the Ramsden Fund. The Ramsden and Earth Science funds are also providing support for quite a few of our majors to pursue exciting research projects with our faculty, and on p. 13 you can find brief summaries of some of their projects. EPS graduate students continue to excel and their research takes them to field areas, or laboratory facilities around the world. I want to highlight EPS graduate student Leif Karlstrom as the very first recipient of the Graduate Student Field Studies award, donated by Dr. Philip Behrman (Ph.D., 1978). His donation was leveraged by a match from the UC Berkeley Graduate Division, an option available to other donors. Leif's independently developed field project is based in Alaska, where he and undergraduate student Adam Zok explored supra-glacial streams at two glaciers on the Juneau Icefield (see p. 12).

As Chair, I feel extremely lucky to serve at a time when we have the most excellent and dedicated technical and administrative staff at EPS. We could not easily educate our students or do first-rate research without their support.

Please, never be shy about staying in touch with updates on your own whereabouts and activities, and with thoughts about how we can make EPS work best. We realize that the internet and e-mail are now the dominant forms of communication; therefore, please do keep us up to date on your electronic contact information so that we can also send you links to this newsletter and future updates via e-mail. Let me end by thanking Doris Sloan, Judith Coyote, Micaelee Ellswhyte, and Anna Reeser for their great work on developing this latest edition of our Alumni Update.



photo by Marge Winn

Department chair Roland Bürgmann (left) and Vice-Chair Michael Manga at the welcoming barbecue.

Roland Bürgmann

DEPARTMENT FACULTY RESEARCH ACTIVITIES



Allen, Richard M., Associate Professor, Ph.D., 2001, Princeton University. Developed new seismic velocity models of the western US that image a whole mantle plume beneath Yellowstone burning a hole through the Juan de Fuca slab and the North American continent.



Alumbaugh, David L., Adjunct Professor, Ph.D., 1993, UC Berkeley. Completed a model resolution analysis of marine electro-magnetic exploration technologies currently being employed to de-risk petroleum drilling in deepwater environments.



Alvarez, Walter, Professor, Ph.D., 1967, Princeton University. Gave the annual campus Faculty Research Lecture in April, about Earth History and Big History, introducing the zoomable timescale of the entire past, "ChronoZoom" (search for it on the web!).



Banfield, Jillian F., Professor, Ph.D., 1990, Johns Hopkins. Geomicrobiology, microbial ecology and evolution; nanoparticles in the environment.



Berry, William B.N., Professor, Ph.D., 1957, Yale. Climate and related environmental changes and mass extinctions; Bay Area watershed and wetlands restorations; K-12 environmental science education; hypoxic-anoxic environments.



Bishop, James K.B., Professor, Sc.D., 1977, MIT/WHOI Joint Program in Oceanography. Chemical, physical, and biological controls on the cycles of carbon and related chemical species in the ocean; robotic instruments for ocean exploration.



Boering, Kristie A., Associate Professor, Ph.D., 1992, Stanford University. Atmospheric chemistry and climate; field, laboratory, and modeling studies of the stable isotopic compositions of atmospheric trace gases; photochemical isotope effects.



Buffett, Bruce, Professor, Ph.D., 1991, Harvard University. Developed new turbulence models for use in numerical simulations of the Earth's geodynamo.



Bürgmann, Roland, Professor, Ph.D., 1993, Stanford University. Explored earthquake cycle deformation in California, Tibet and Sumatra using GPS and radar interferometric satellite data.



Chiang, Eugene, Professor, Ph.D., 2000, Caltech. Performed numerical simulations of how dust grains sediment in circumstellar disks to form planetesimals.



Clark, Simon, Associate Adjunct Professor, Ph.D., 1990, Birkbeck College, University of London. Mineral physics; high-pressure experimental geophysics; structure and dynamics of planetary interiors.



Cohen, Ronald C., Professor, Ph.D., 1991, UC Berkeley. Studied the role of soils and fires in the atmospheric nitrogen cycle using space-based UV-visible spectroscopy.



Collins, William D., Professor in Residence, Ph.D., 1988, University of Chicago. Global climate models; interactions of sunlight and heat with the Earth's surface and atmosphere; applications of remote sensing to understand climate processes.



Cuffey, Kurt M., Professor, Ph.D., 1999, University of Washington. Glacier mechanics; paleoclimatology; environmental isotope geochemistry; river processes.



DePaolo, Donald J., Class of 1951 Professor of Geochemistry, Ph.D., 1978, Caltech. Now directing a DOE Energy Frontier Research Center for fundamental research to facilitate large scale geologic carbon sequestration.



de Pater, Imke, Professor, Ph.D., 1980, University of Leiden. Radio and infrared observations of the Solar System, including giant planet atmospheres and Jupiter's magnetosphere.



Dietrich, William E., Professor, Ph.D., 1982, University of Washington, Seattle. His research group showed experimentally the necessary conditions for sustained river meandering and presented a theory predicting valley spacing.



Dreger, Douglas S., Professor, Ph.D., 1992, Caltech. Wave propagation; earthquake source physics; earthquake hazards; realtime seismology; nuclear monitoring.



Fung, Inez Y., Professor, Sc.D., 1977, MIT. Climate change; global carbon cycle; geophysical fluid dynamics and large-scale numerical modeling; remote sensing of the Earth.



Ingram, B. Lynn, Professor, Ph.D., 1992, Stanford University. Completed a study using oxygen and carbon isotopes in varved lake sediments from the Gulf of California for assessing Holocene changes North American Monsoon and past solar variability.



Jeanloz, Raymond, Professor, Ph.D., 1979, Caltech. Turned helium and diamond into fluid metals above pressures of 1 and 10 Mbar, respectively, in line with theoretical predictions applied to the interiors of giant planets.



Kirchner, James, Professor, Ph.D., 1990, UC Berkeley. On leave in Switzerland; developed new methods for using fluctuations in stream flow to infer rainfall and evaporation rates in watersheds.



Manga, Michael, Professor, Ph.D., 1994, Harvard University. Published a book with Chi Wang on "Earthquakes and water" - showed that many hydrologic responses to earthquakes are caused by permeability changes produced by shaking.



Militzer, Burkhard., Assistant Professor, Ph.D., 2000, University of Illinois. Demonstrated the existence of helium rain on Jupiter. The Galileo spacecraft measured an unusual neon depletion. Computer simulations showed that neon is sequestered by helium rain.



Pride, Steven R., Adjunct Professor, Ph.D., 1991 Texas A&M. Developed new models for how seismic waves can mobilize liquid pollutants and hydrocarbons trapped on capillary barriers in porous media and applied these models to a test site in Oklahoma.



Rector, Jamie, Professor, Ph.D., 1990, Stanford University. Seismic techniques for characterizing reservoir properties and processes; seismic reflection imaging; borehole seismology; near-surface seismology with applications to environmental remediation.



Renne, Paul R., Professor in Residence, Ph.D., 1987, UC Berkeley. Launched an NSF-funded project to build a "designer" reactor based on deuterium fusion to produce a high flux of nearly monoenergetic neutrons for Ar/Ar geochronology.



Richards, Mark A., Professor, Ph.D., 1986, Caltech. Mantle convection and large-scale mantle structure; dynamics of terrestrial planets; dynamics of global plate motions; regional crustal deformation and earthquake hazards.



Romanowicz, Barbara A., Professor and Director, Berkeley Seismological Laboratory, Doctorat d'Etat, 1979, Université de Paris. Used anisotropic wave-form tomography to reveal two distinct layers in the lithosphere under the North American craton.



Sloan, Doris, Adjunct Professor, Ph.D., 1981, UC Berkeley. Biostratigraphy; history of San Francisco Bay; introduced species in the Bay; regional geology.

EMERITI



Brimhall, George H., Professor, Ph.D., 1972, UC Berkeley. Completed geological mapping in the Pioneer Mountains of Montana where a Cretaceous formation bears evidence of early uplift of the Rocky Mountains.



Bukowski, Mark S.T., Professor Emeritus, Ph.D., 1975, UC Los Angeles. Physics and chemistry of planetary interiors; mineralogy; high pressure mineral physics; planetary structure and evolution.



Carmichael, Ian S.E., Professor Emeritus, Ph.D., 1960, University of London. Igneous petrology; analytical chemistry of volcanic rocks; experimental studies of silicate melts; geologic evolution of western Mexico and the western Basin and Range.



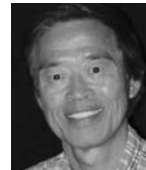
Curtis, Garniss H., Professor Emeritus, Ph.D., 1951, UC Berkeley. Founder of the Berkeley Geochronology Center; Geochronology and volcanology; K/Ar and Ar⁴⁰/Ar³⁹ dating and application to geologic timescale.



Johnson, Lane R., Professor Emeritus, Ph.D., 1966, Caltech. Seismology and physics of the Earth's interior and wave propagation; seismic source theory; applied geophysics.



Morrison, H. Frank, Professor Emeritus, Ph.D., 1967, UC Berkeley. Applied geophysics: electrical and electromagnetic methods for mapping subsurface conductivity; cross-well electromagnetics for reservoir characterization; numerical modeling and inversion.



Wang, Chi-yuen, Professor, Ph.D., 1964, Harvard University. Tectonophysics; heat and fluid transport in the Earth; hydrological processes during earthquakes; hydrological processes on Mars; crustal deformation in active tectonics.



Wenk, Hans-Rudolf, Professor Emeritus, Ph.D., 1964, University of Zurich. Focus has been on anisotropy in the deep earth, both with high pressure experiments and modeling. In summer he got close to finishing an old mapping project in the Alps.

FIRST JOLT: WARNING FOR THE NEXT BIG EARTHQUAKE IN CALIFORNIA

by *Richard M. Allen*

The Berkeley Seismological Laboratory hosts many tour groups interested in learning about earthquakes. Some are interested in remote sensing of Earth structure, and some are interested in characterization of the seismic source. All are interested in hearing about past earthquakes, and there is one question that every visitor asks: When will we have the big one?

Earthquake prediction is not possible, and most earthquake scientists do not think it will become possible in the near future. However, while we cannot provide a few days', or even hours' warning, it is now possible to provide a few seconds, perhaps up to one minute of warning time. This is what is called earthquake early warning (EEW). The idea is to use geophysical networks distributed across earthquake-prone regions to rapidly detect earthquakes, locate them, estimate the magnitude, and predict the shaking intensity -- all before the shaking reaches you.

What use is a few seconds' warning? It is enough time for individuals to dive under a sturdy table to protect themselves from falling lighting fixtures, broken windows, bookcases and any other debris. For those working with hazardous machinery and chemicals, it is enough time to move to previously determined safe zones. Eye surgeons can step back from their patients, and micro-robots can stop punching chip components, both preventing serious and costly damage during shaking. Trains can stop, and planes can go around rather than landing on shaking ground. There are many applications, all of which will reduce the overall impact of the next big earthquake.

To make EEW possible we must rapidly detect earthquakes and determine whether they are likely to produce damaging ground shaking. Berkeley's seismic networks detect hundreds of earthquakes every day. It is the big events every few years that we want to distinguish. So how quickly can we determine the magnitude of an earthquake?

Using seismic data from earthquakes around the world, we have developed empirical scaling relations that provide a rapid estimate of magnitude. They use the amplitude and the frequency content of the first few seconds of the first energy pulse arriving at the surface -- called the P-wave. This approach works well for earthquakes up to about magnitude 7, and for the same events we can approximate the shaking intensity as a radial function around the epicenter. In bigger earthquakes very long sections of the faults will rupture—about 400 km for the 1906 magnitude 8 San Francisco earthquake—and the ruptures last tens of seconds. For these events, we want not only to detect them and estimate the

magnitude, we also want to map the fault as it ruptures in order to provide accurate estimates of ground shaking.

These practical questions, that must be answered for an EEW, immediately lead to fundamental questions about the physics of earthquake rupture. Can we predict the magnitude of an earthquake before the rupture is complete? Is the area of the fault that will slip in the dynamic rupture defined by a preparatory aseismic process? Do big earthquakes start with big slip pulses, or do they all start small? Do big earthquakes only occur on big, mature faults, while small earthquakes are on juvenile, ancillary faults?

To answer these questions, new observations of the earthquake rupture process are needed. The challenge is to have dense geophysical instrumentation deployed adjacent to a fault at the right time to capture the process of a big earthquake. The same dense instrumentation can be used for an EEW system. The state-of-the-art instrumentation needed to facilitate research into the earthquake process can also provide warning of the earthquake when it is underway.

Today, we are in the process of implementing a prototype EEW system for the state of California with our collaborators in the California Integrated Seismic Network (CISN.org). Initial testing using the empirical relations described above show that EEW is possible now. In the next year, we will start to deliver alerts to a small group of test users. This testing is necessary to develop the right infrastructure for a warning delivery system. The system could be extended and made publically available (see figure). But to make the warnings as robust as possible, the next generation of geophysical networks is needed. The same instrumentation can provide earthquake alerts to all of California and also provide the necessary data to better understand the earthquake process.

Smart phones are an ideal way to deliver earthquake alerts. The phones know where they are located, so having received a message that an earthquake is underway, they can determine how serious the shaking will be at the location of the phone and provide a visual, and audible, alert.



September 20, 2010

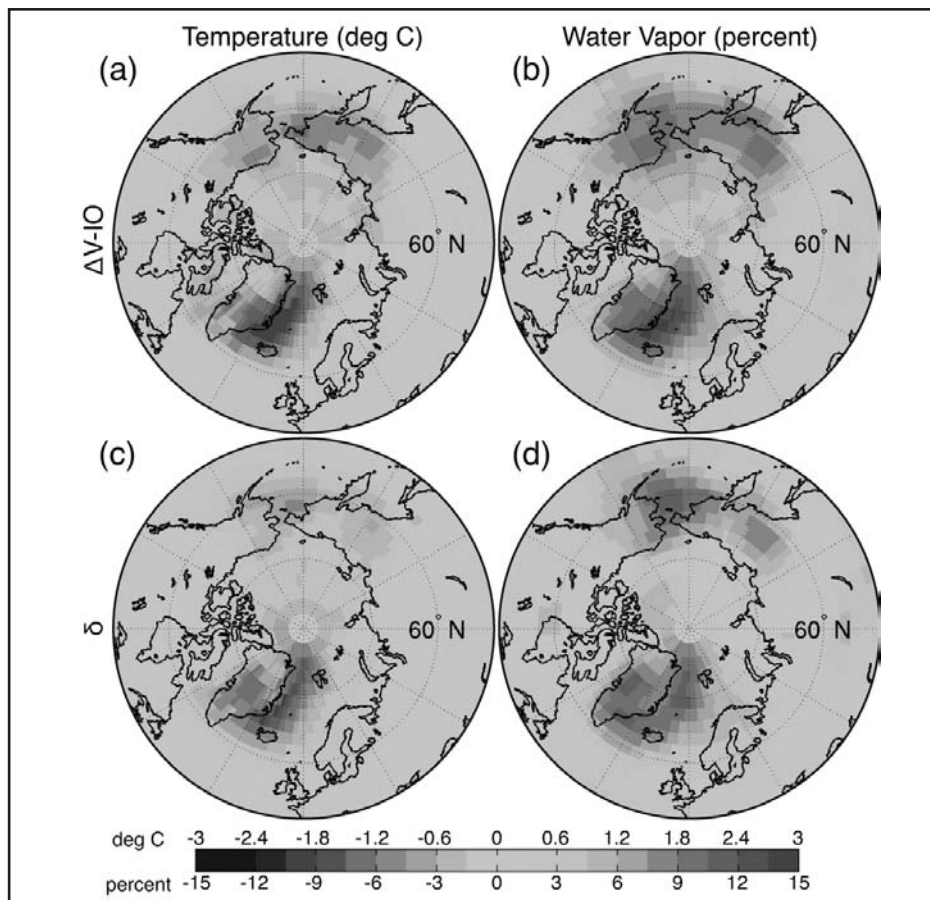
ECOCLIMATE TELECONNECTIONS

by Inez Fung and Abigail Swann

The land surface interacts with the climate via the exchange of energy, water, carbon dioxide and other trace constituents. The exchange is determined by the states of the climate and the land surface, and in turn, alters their states. Land cover has changed in response to climate change, as well as to human modification. As the tree line migrates poleward in response to global warming, large scale tree plantings are being considered as a possible climate mitigation strategy.

To investigate the climatic consequences of large-scale afforestation, we carried out a series of experiments with the global climate model of the National Center for Atmospheric Research, where we modified the land cover. Two model oceans were incorporated into the model. The “interactive ocean” (IO) is a mixed layer ocean of fixed depth whose temperature responds to changes in energy fluxes, but has prescribed heat transport. The “fixed ocean” (FO) has prescribed sea surface temperature and sea ice cover. The first experiment replaced bare ground within the Arctic Circle with deciduous trees. The traditional view is that the movement of trees into the Arctic will have a warming effect only in the afforested regions. However, we found that replacing the tundra with trees will also melt sea ice and greatly enhance warming in the entire Arctic region (Swann et al., PNAS 2010).

Because trees are darker than the bare tundra, the northward expansion of trees results in greater absorption of sunlight and a consequent local warming. Furthermore, broad-leaved trees also transpire significant amounts of water, and water vapor is a greenhouse gas that is well-mixed throughout the Arctic. The combined effect of lower albedo and increased transpiration leads to a positive feedback loop. As the air warms, it can hold more water vapor. The enhanced greenhouse effect leads to melting of sea ice, increased absorption of sunlight, and increased evaporation from the open ocean. This positive feedback will warm the land even more and encourage faster, more efficient tree growth and perhaps a faster expansion into the Arctic. An additional 1 degree Celsius increase in temperature occurs over the Arctic as a result of the Arctic land cover change only. The warming is modest compared to the projected Arctic warming of 5-7 degrees Celsius within the next 100 years as a result of increases in fossil fuel emissions but the results suggest that the land cover feedback will accelerate the warming.



(a) The anomaly ($\Delta V-IO$) in near-surface atmospheric temperature in degrees Celsius (deg C) between a model experiment where trees are introduced on bare ground north of $60^\circ N$ and a corresponding control run with no added trees.

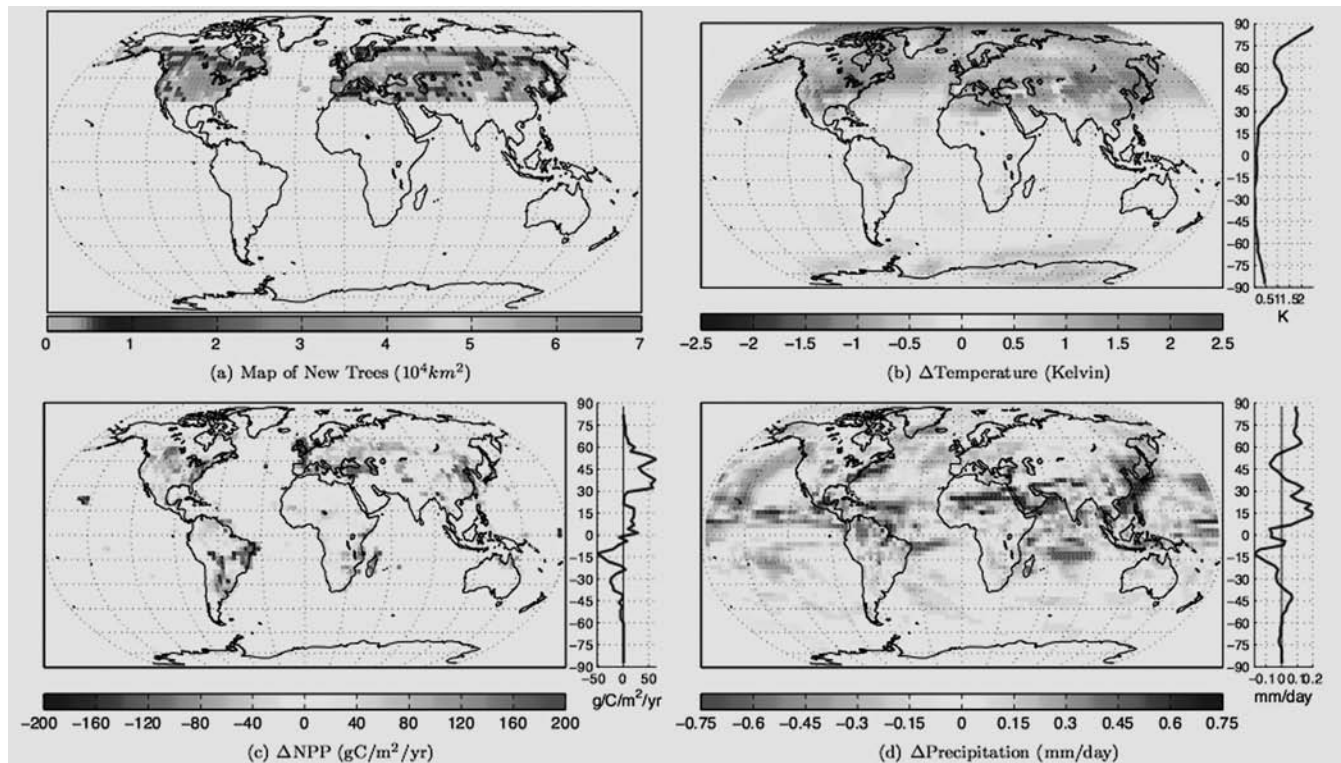
(b) The same as (A) for column water vapor in percent.

(c) The difference $\Delta(\Delta V-IO - \Delta V-FO)$ in near-surface atmospheric temperature in deg C between two anomalies where trees are introduced on bare ground north of $60^\circ N$, one with an interactive ocean model (V-IO), and the other with fixed ocean and sea-ice (V-FO).

(d) The same as (C) for column water vapor in percent.

The experiment with afforestation in mid-latitudes of the Northern Hemisphere replaces all present-day grasslands and croplands between 30-60°N with deciduous trees (Swann, 2010). To start, the northern hemisphere warms, mainly because the trees are darker than the plants that precede them. The greenhouse effect is less significant, without assistance from the Arctic Ocean. The surprise is that the Intertropical Convergence Zone (the tropical rainbelt) shifts northwards, leading to a wetter Sahara Desert and a drier southern edge of the Amazon Forest. Our analysis shows that the Hadley circulation strengthens and shifts northward so as to redistribute energy southwards.

Our model results for the Arctic are corroborated by present-day and paleo-ecologic data. Alaska is already getting shrubbier. In the emergence from past cooling, e.g. around 11,000 years ago, deciduous trees established their range more rapidly than needle-leaved trees. We hypothesize that there are “pioneers” – like shrubs, and deciduous trees – that modify the climate until it is comfortable, and then the whole clan moves in. Furthermore, we hypothesize that mid-latitude expansion of tree cover, especially in Europe (Prentice and Webb, 1998), may have contributed to the greening of the Sahara during the mid-Holocene.



(a) Map of area of new deciduous trees in mid-latitude afforestation experiment in units of $10^4 km^2$. New vegetation is added on C3 grasslands and cultivated land between 30 °N and 60 °N. The total area converted is $1.8 \times 10^7 km^2$. The anomaly in (b) near surface temperature (ΔT) in Kelvin, (c) net primary productivity ($gC/m^2/yr$), and (d) precipitation in mm/day for a model experiment where trees are introduced as in (a) with an interactive ocean.

Swann, A. L., I. Y. Fung, S. Levis, G. B. Bonan, and S. C. Doney, Changes in Arctic vegetation amplify high-latitude warming through the greenhouse effect, *Proceedings of the National Academy of Sciences of the United States of America*, 107 (4), doi:DOI 10.1073/pnas.0913846107, 2010.

Swann, A. (2010) *Ecoclimate: variations, interactions and teleconnections*. PhD Thesis, UC Berkeley.

Prentice, I., and T. Webb, BIOME 6000: reconstructing global mid-Holocene vegetation patterns from palaeoecological records, *Journal of Biogeography*, 25 (6), 1998.

EPS GAINS EXPERIENCE WITH ONLINE TEACHING

by Burkhard Militzer

Online teaching was a hot topic at the recent meeting of the UC regents. While it appears to be very promising to some in the university administration as a way to reach out to many more students and to increase revenue, it has been controversial to many others. A diversity of opinions is present on campus and in our department.



photo by UC Extension

Burkhard Militzer (left, EPS, Astronomy) and Geoff Marcy (Astronomy) in an introductory class video.

Since Geoff Marcy (Astronomy) and I have just completed teaching “The Planets” online for the first time, I would like to share my experiences with you. Last fall, we were approached by the chairs in Astronomy and EPS to offer an online version of the very successful course “The Planets” that has been cross-listed by the two departments for many years and has drawn 200 students or more each semester. The goal of offering a summer online course in addition to our face-to-face class was to reach out to a large number of non-science majors who spend the summer off campus but have extra time to fulfill requirements. That is where I see the positive side of this online class. Students who would otherwise just be working can now also make progress toward their degrees. Nobody we spoke with suggested replacing our face-to-face course, but I will critically compare the two below. The fact that it took the committee on courses three sessions to approve our class indicates that online courses are controversial on campus.

As far as motivations go, there is also a financial aspect. From the fees of 100 students enrolled into our class, both departments will share a benefit equivalent to 25 phone lines per year, according to my rough estimate. This unusual financial unit is somewhat appropriate because phone lines have been the target of recent budget cuts.

Our online course consisted of pre-recorded lectures, threaded discussions, online and written homework as well as office hours. We used the same textbook as in the face-to-face class, “The Cosmic Perspective.” Geoff and I sat down in front of our computer and recorded all our PowerPoint lectures again for the online delivery. We produced video files based on our slides that included our explanations, some animations, cursor movement and whatever we decided to draw on the screen. This was a lot of work but also offered room for creativity. It was Geoff’s idea to introduce “Star talk” that would bear some accidental similarities to a certain radio show. Adding humor, music, and sound effects to the recordings was our attempt to make it more appealing to students. “We will we will rock you” and “Under pressure...” respectively concludes the lectures on earthquakes and minerals. You can view two lecture examples at <http://militzer.berkeley.edu/L21.mov> and <http://militzer.berkeley.edu/L.mov>

I would say our lecture recordings were successful. The content was the same as in our face-to-face class. However, the interactive part was missing. Students did not see us perform in real time, which is far from optimal but is a compromise I am willing to make in order to reach out to more students in an online setting. (I am listening to CDs much more often than I go to concerts but admittedly all classes that had an impact on me were delivered in real time.) Moreover, in our face-to-face class, only a few out of 200 students use the chance to ask questions. Some surreptitiously surf the internet while they attend our lecture.

I see the biggest difference between an online and a regular class in the discussion format. In a threaded discussion as opposed to the conventional weekly discussion sections, students were asked to post one or two paragraphs about a given topic. Later, they needed to reply to a fellow student’s posting and both components were graded. This worked best when students posted and explained images they found on GoogleMars. Some said they spent a whole night on Mars. However, when I wrote detailed replies to students’ postings, it was disappointing to see how few responses I received. There was no real discussion. Students had already moved on after having fulfilled this assignment.

Every week students had to do homework with the online system MasteringAstronomy. It is graphical and interactive and provides instant feedback. I made sure that we still had homework submitted by email in order to

continued on p. 9:

DEPARTMENT ANALYTICAL FACILITIES THEN AND NOW

by Tim Teague

Today's researchers can choose from a multitude of analytical techniques that didn't exist when I came here in the late 1970's. Many of these are found off campus in specialized facilities such as the Advanced Light Source at LBNL. Superficially, the department labs have remained fairly constant over the years. We still do bulk chemistry and phase identification with XRD and XRF, microanalysis with an electron microprobe, and we've almost always had an electron microscope. The big difference is how labor-intensive the equipment used to be. A good example is the x-ray diffractometer. The main way to get the data was from a chart recorder, which was an analog device that existed long before computers (below left). We used to measure peak locations manually on the chart, convert the data using a primitive calculator and consult search manuals and card files to identify the minerals. The measurements and calculations are automatic on today's system, and the equivalent of 150,000 library cards are stored on the computer. What once took hours can sometimes be done in seconds with today's computerized system (below right).



In general the quality of the data has improved along with the increased speed. The exception to this is the other way chemical analysis was done here - wet chemistry by Ian Carmichael. Although it's faster and easier to do this today by XRF, the quality of his analyses hasn't been equaled. In fact, we still use his carefully analyzed rock powders as calibration standards for the XRF.



continued from p. 8:

develop skills that a machine cannot evaluate, e.g., essays, detailed calculations, and exploring Mars.

Students also had the option to email us questions and to attend electronic office hours but both were very seldom used. We as instructors felt somewhat detached from our students. We met most of the students only once when they took the written final exam on campus. Others took it at a proctoring service elsewhere. We also constructed two online midterm exams but that did

not work as well as expected. We could not control access to the internet during the midterm exam and we also found that a disproportionately high number of students engaged in illegitimate collaborations.

If online teaching is to play a more prominent role in university teaching, then having an interactive component

will be essential. Since we already have wonderful software tools that allow us to have group discussions with audio and video, file and screen sharing, for certain courses, there may no longer be a need for instructors and students to be at the same place. Still, the value of interactive teaching has not disappeared. On the contrary, since so much is prerecorded, the interactive part will have to be carefully constructed to compensate for the lack of human communication.

Our course evaluations for this year were very positive. For next summer when we expect a higher enrollment, we are thinking about how to add an interactive element to the course. The challenge will be to accommodate everyone's schedule but still to make this a more engaging online experience.

CalDay visitors freezing a rose in liquid nitrogen at Burkhard Militzer's lecture on "Jupiter and its icy moons-fun with liquid nitrogen."
Photo by Mong-Han Huang



NEWS FROM EMERITI FACULTY

Rudy Wenk



Looking back at my first year of retirement, I can only conclude that I have never been busier. The reason is psychological: No more excuses not to engage in whatever is interesting. And there is a lot: Deformation in the lowermost mantle, approached both with diamond anvil cells and modeling. Then the anisotropy in shales continues to be fascinating and sometimes frustrating. A formidable project is the microstructure of cement minerals, most recently the nanostructure of “amorphous” Ca-carbonate that turns out not to be amorphous. A nice intermezzo was the geometry of magnetite precipitates in plagioclase. In summer I finished my longstanding mapping project in the Alps. I could go on but the word limit has been reached. Retirement continues to be fun thanks to my students and colleagues.

Garniss Curtis



At age 91 I'm still very interested in science and have just completed a paper, “Strong Geomorphic Evidence for Early Life on Mars.” As soon as I complete the bibliography I shall put it on my website and send it to Yahoo or some other of the popular biggies. This paper may be hard for any one to accept with little knowledge of Mars or of geomorphology. I'm also taking up a geologic problem I started on over 50 years ago and worked on intermittently over the years. This is the collapse caldera that the Lawrence Berkeley Lab sits on. They are quite upset with me about this and are trying to refute me. As all my surgeries (two cancers and one open-heart to mend a valve murmur) have virtually destroyed my balance, I would be happy to turn this problem over to a graduate student and give him my data, which needs much checking. Properly done, this is a Ph.D. problem. I have another superb Ph.D. problem, which combines seismology with field geology. I have written to Emily E. Brodsky at Santa Cruz

who had a very interesting paper in *Eos* about drilling into faults immediately following earthquakes. If she doesn't want my problem, trust me, this is a golden opportunity to make one of the most important contributions to both seismology and geology in many years.

Chi Wang



For this year I would like to mention the following: 1. The appearance of our (Wang and Manga) book “Earthquake and Water,” published by Springer. 2. Co-teaching of EPS 200 with Michael on mud volcanoes and geysers. The highlight of the course was a field experiment conducted at the Calistoga Old Faithful geyser, that involved many different kinds of instrumental recording. 3. A significant increase of number of students enrolled in EPS 50 last Spring - to 51 (over the set upper limit of 50) from 46 in Spring, 2009.



A scene from the Calistoga experiment showing the measurement of the discharge from a pool around the Calistoga geyser. Standing are two EPS graduate students, Ben Andrew and Jennifer Frederick, and USGS scientist Darcy McPhee. The wooden weir was constructed at our department machine shop by John Werner.

Coming to AGU? Join us for the annual
Santa Barbara's Day Celebration

Saturday, Dec. 11, 2010

6 p.m. - 10 p.m. in the Toll Room of the Alumni House

For more information and to purchase tickets, please contact Joanne Emerson at jemerson@berkeley.edu.

ALUMNI NOTES

1957 John R. Hunt- Ph.D. Geology

I am working as a consulting geologist. My specialties are porphyry exploration and mine geology.

1958

Stan Cebull- BA 1957, MA 1958 Geology

Brief synopsis: Texas Petroleum Company, Venezuela; Ph.D, University of Washington (1967); Department Geosciences, Texas Tech University, 1967-2000. Now retired Emeritus. – You should have kept Bacon Hall.

1968

James Murray- BA Geology

I became a Fellow of the AGU this year.

1976

Craig Robertson- BA Geophysics

Hello to all. As the years pass & the hair, what's left, grays, I continue to value the memories of my time at UCB. For clarity, those who knew me then knew me under my other last name, Rosenbaum (long story). I was among the group of students who named the philodendron in the grad student offices, Babs's (after Bruce A. Bolt). I have recently become the author of science fiction as well a podcast contributor to 365 days of Astronomy. You can check out my podcast novels at Podiobooks.com (free) and their ebook counterparts on Amazon.com (\$5). Look for Anon Time, The Innerglow Effect, and Prisoner of NaNoWriMO. Have a great year!

1977

Chuck Ensey- BA Geology

Now working for Wells Fargo Advisors in San Diego, mostly buying corporate and municipal bonds for clients and an occasional stock. I have always had an interest in oil stocks after having worked in the oil field from 1978-1985. I enjoy reading about geology, two of my favorites are John McPhee's books like "Basin and Range" and Bill Bryson's "A Short History of Nearly Everything". I also enjoy watching "The Universe" and "How the Earth was Formed" on the History channel. I was happy to see classmate Cathy Busby on TV a while ago.

1978

Clifford S. Rainey- BA 1974 Geology, MS 1978 Geology
Please visit <http://www.csrainey.com>. Click on "Elegensis" or "Origins of Matter."

David A. Seeburger- BA Geophysics

Taking early retirement as of 10/30/09.

1986

Rob Williamson- BA Earth Science

I have retired from the Air Force Reserves after 23 years of service. I continue to work as an airline pilot for Alaska Airlines. I love hearing about what's happening with UC Berkeley and EPS, especially since I grew up in Berkeley and spent much time on campus (my father taught in Civil Engineering).

1997

Jesse Schwartzberg- BA Earth Science

I am currently working as a designer at a green design-build firm in Portland OR called Green Hammer. I graduated from the University of Oregon with a Masters degree in Architecture in 2004 after working as a carpenter for 6 years in the Adirondack Mountains of upstate NY. I am currently working toward my architecture license in NY and OR.

2005

Arthur Reis- BA Geophysics 2002, MS Geophysics 2005

I have been working at the Department of Energy's Federal Energy Regulatory Commission in the hydropower engineering group for over a year. Laura Glaser (Geology '01) and I meet often to discuss developments in hydropower and nuclear energy consulting.

IN MEMORIAM

George Switzer (BA Geology, 1937) died in 2008

Robert Leon Rose (BA Geology, 1948; PhD Geology 1957) died November 1, 2009

Eric Essene (PhD Geology, 1967)

Eric J. Essene passed away on May 20, 2010, at home, following a courageous battle with cancer. Eric Essene completed his Ph.D. at the University of California, Berkeley, in 1967 under the direction of William S. Fyfe. He joined the University of Michigan as an assistant professor in 1970, where he enjoyed a very productive and distinguished career, retiring in 2009 as the William C. Kelly Chair of Geological Sciences. Author of well over 200 scientific publications in peer-reviewed journals, Professor Essene made numerous and profound contributions in broad areas of mineralogy, petrology, and geochemistry. Eric Essene received many awards and honors, including the Bowen Medal in 1991 by the American Geophysical Union; the first Sokol Award in 1993 for excellence in graduate education of the sciences from the University of Michigan; and the Mineralogical Society of America in 1981, and Fellow of the American Geophysical Union in 1991. For the last several years Eric has not been able to attend scientific meetings. He has kept in touch with the scientific community – often daily – through the MSA talk list. The MSA talk list enabled Eric to continue to engage fully in the intellectual discourse at which he clearly excelled and which he deeply loved. Our scientific community has lost a vibrant and dynamic colleague who possessed a keen, adventuresome intellect. He will be greatly missed!

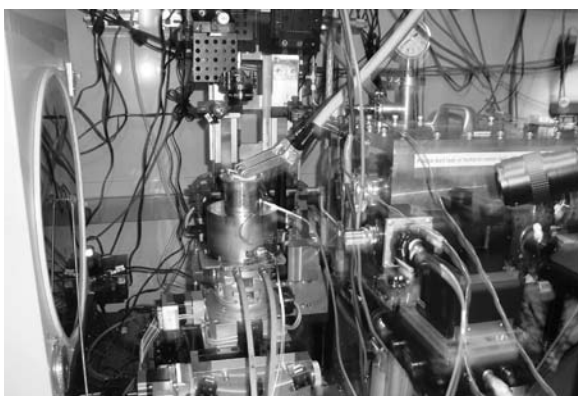
John Bowman

STUDENT RESEARCH

Pam Kaercher - 2009-2010 Francis J. Turner Fellow

This past year I was able to watch the phase transition in FeO during compression in a diamond anvil cell, see twinning in hafnium at APS at Argonne National Laboratory in D-DIA (multi-anvil compress), and in March, I was involved in the first radial diffraction experiment that combined laser heating and internal resistive heating! During the summer I studied twinning in deformed and shocked quartz samples with EBSD, attended Neutron school at Los Alamos National Laboratory and returned twice more to APS for another heating experiment with perovskite and additional D-DIA experiments with hexagonal metals. I am just starting my second year in graduate school and looking forward to the year ahead!

photo by Simon Clarke



Heating experiment at the resistive heating diamond anvil cell at the Advanced Light Source

photo by Kittichai Soijphan



Pam Kaercher at Bandelier National Monument near Los Alamos

Leif Karlstrom - 2009-2010 Graduate Student Field Support Fund recipient

photo by Adam Zok



EPS Graduate student Leif Karlstrom installing a Distributed Temperature Sensor on the Mendenhall Glacier, AK

Between July 22 and August 12 of 2010, EPS undergraduate Adam Zok and I conducted a study of supraglacial streams at two glaciers on the Juneau Icefield, in southeast Alaska. Representing a primary component of glacial hydrology, these streams form during the melt season as surface melt water thermally erodes channels into the glacier surface. We studied the flow characteristics and morphodynamics of supraglacial streams on the Mendenhall and Llewellyn glaciers, utilizing new technology as well as the standard tools of fluvial geomorphology to make our measurements. The trip was quite successful; we observed diurnal cycles in discharge and water temperature, collecting data on channelization processes as well as water samples for isotopic analysis. The data we collected will help constrain mathematical models for meander formation and channel spacing in supraglacial streams, and as such fulfills a personal objective to connect theoretical models directly to field observations. The expedition further provided Adam Zok and me with valuable remote fieldwork experience and will no doubt lead to further opportunities in glacial research. I thank the Berkeley EPS department, the Behrman fund, and the Geological Society of America for financial support, without which this trip would not have been possible.

Four EPS undergraduates were supported by Ramsden Scholarships in 2009-10. Here are their reports.

Julia Hassen - Marine Science

During the summer of 2010 I have been working on a project with Ph.D. student Maya DeVries, who is using stable isotope analysis to better understand



Julia dissecting prey muscle tissue.

links between diet and morphological speciation in mantis shrimp, also known as stomatopods, by comparing muscle tissue from potential prey items to stomatopod muscle tissue. I have a strong passion for art, science and education, so in order to combine these interests, I am also writing and illustrating a children's book series on stomatopods, covering scientific concepts such as molting, polarization, predator and prey relations. I am also covering social and political issues like pollution, the oil spill and human-induced invasive species. Since mantis shrimp are not widely known, we also maintain a Facebook outreach page to promote stomatopod awareness.

Juliana Spector - Geology

Support from the Ramsden Grant allowed me to travel to Burlington, Vermont for eight weeks this summer to participate in research working on local solutions to the effects of climate change. Through a program called Summer of Solutions, I worked on several major projects, the most notable being assisting with the construction of a

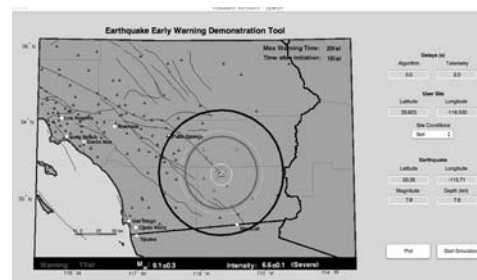


Wall in the refrigerator being filled with bottles by Juliana and another intern.

passive freezer-refrigerator. The passive freezer-refrigerator project aimed to create a food storage system that did not require energy to be put into it (i.e. electricity) to keep food cool or frozen. The walk-in freezer-refrigerator was built with 3000 2 liter soda bottles filled with saltwater solution lining the inner walls and Styrofoam on the outer walls to provide insulation. This super insulated, underground room had ceiling hatches that would be opened in the winter to allow cold air to seep in and freeze the bottles. According to modeling, these bottles would stay frozen year-round to provide a cooling system for the room. The project will continue with further monitoring of the effectiveness of this passive system for freezing and cooling food.

Magali Barba - Geophysics

During this past summer, through the Southern California Earthquake Center Summer Undergraduate Research Experience and the Charles H. Ramsden Endowed Fund, I interned at the California Institute of Technology Seismological Laboratory. Maren Bose, Egill Hauksson, and I developed the Earthquake Early Warning Demonstration Tool (EEWDT) to assess the potential performance of an EEW system in California based on the τ_c -Pd algorithm. For a given earthquake scenario, the EEWDT displays the real-time P- and S-wave propagation, the stations that have recorded and transferred data (depending on the processing and telemetry delays specified), the estimated magnitude and epicenter location and corresponding uncertainties. The EEWDT also shows the warning-time available at a given user location, as well as the estimated seismic intensity at this site.



The image shows the EEWDT. By varying the delay, user site, and earthquake parameters, the user can customize the earthquake scenario.

Adam Zok - Atmospheric Science

Thanks to the Ramsden Scholarship, I was able to travel to the Juneau Icefield in Alaska for three weeks this summer with UC Berkeley graduate student Leif Karlstrom to collect data on supraglacial meltwater streams. By measuring quantities such as water temperature, discharge, drainage density, ablation rate and water table depth, we hope to make improvements on recently developed models for the formation and evolution of such streams. In addition, I collected a number of water samples for isotopic analysis and will look at how isotopic ratios vary depending on time of day, stream size and source (melted ice, rain, stream water, etc). Not only has my experience in Alaska been both enjoyable and academically enlightening, and it left me more excited than ever about continuing to study glaciers in graduate school.



Adam Zok, making discharge measurements in a supraglacial stream on the Mendenhall glacier, Alaska.

COMMENCEMENT 2010

BACHELOR OF ARTS

ATMOSPHERIC SCIENCE
Nathaniel Wilkins Chaney
Anh Vu Trinh Doan
Brandon Karl Johnson

ENVIRONMENTAL EARTH SCIENCE

Myra Elizabeth Anderson
Lauren Michelle Burns
Giancarlo Cretaro
Fanxiang Jin
Alan Kuoch
Jonathan Joseph Mazzeo
Sequoia Alexander Patterson
Eric Rippchen Pennella
Erum Razzak

GEOLOGY

Sandra Desiree Fernando
Matthew Scott Gonzales
Alexander Scott Hartnett
Morgan Mason Jacobs
Colin Joseph McNeece
Rebecca Jean Smith
Michael Walker Whitman

GEOPHYSICS

Jason Paul Chang
Daniel Weston Feucht
Hunter Scott Philson
Kiran Jayant Sathaye

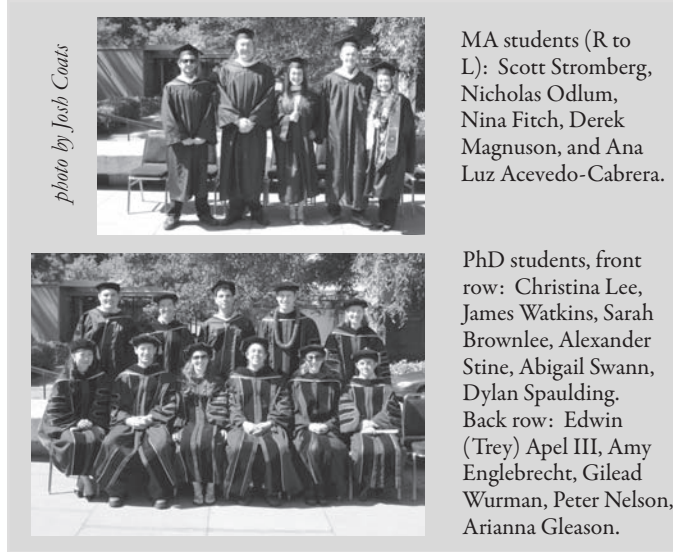


photo by Josh Coats

MA students (R to L): Scott Stromberg, Nicholas Odium, Nina Fitch, Derek Magnuson, and Ana Luz Acevedo-Cabrera.

PhD students, front row: Christina Lee, James Watkins, Sarah Brownlee, Alexander Stine, Abigail Swann, Dylan Spaulding. Back row: Edwin (Trey) Apel III, Amy Englebrecht, Gilead Wurman, Peter Nelson, Arianna Gleason.

MARINE SCIENCE
Harper Clare Ackerman
Shauna Luxmi Badheka
Meredith R. Bayne
Paul Johannes Gierz
Julia Ann Hassen
Coty Tokio Hiraga
Vanessa Blair Lovenburg
Heath McNair
Atif Saleem
Michelle Sue Takata
Libby Te
Sara Gene Walkup

GRADUATE AWARDS

George Louderback Award:
William Cassata

Outstanding Graduate Student Instructor:
Dylan Kenneth Spaulding

Graduate Field Studies Support Award:
Leif Karlstrom

MASTER OF ARTS

Ana Luz Acevedo-Cabrera
Nina Bree Fitch
Derek William Magnuson
Russell Craig McArthur
Nicholas J. Odium
Scott Ryan Stromberg

DOCTOR OF PHILOSOPHY

Edwin (Trey) Victor Apel III
Shells on a sphere: plate boundary deformation from geodesy and block modeling

Sarah Jo Brownlee
Revisiting the Baja-British Columbia hypothesis: 40Ar/39Ar geochronology and paleomagnetism of the Ecstall, Butedale, and Smith Island plutons, British Columbia, Canada

Amy Cathryn Englebrecht
A high resolution record of late Holocene climate change from Isla Isabela, Gulf of California

Arianna Elizabeth Gleason
Elasticity of materials at high pressure

Christine On-Yee Lee
The structure of the solar wind in the inner heliosphere

Peter August Nelson
Sediment sorting and bed surface patchiness in rivers

Dylan Kenneth Spaulding
Exploring planetary interiors with laser-driven shock compression experiments

Abigail Lynn Segal Swann
Ecoclimate: variations, interactions and teleconnections

Alexander Robin Stine
Climate change at annual timescales

James Mervin Watkins
Isotope separation by diffusion in geological liquids

Gilead Wurman
Earthquake early warning and the physics of earthquake rupture



Top row: Colin McNeece, Sandra Fernando, Hunter Philson, Jason Chang, Daniel Feucht, Rebecca Smith, Michael Whitman, Juliana Spector. Middle row: Morgan Jacobs, Matthew Gonzales, Erum Razzak, Sequoia Patterson, Alan Kuoch, Fanxiang Jin, Lauren Burns, Giancarlo Cretaro, Nathaniel Chaney. Bottom row: Cory Hiraga, Sara Walkup, Libby Te, Michelle Takata, Atif Saleem, Heather McNair, Julia Hassen, Paul Gierz, Meredith Bayne, Shauna Badheka, Harper Ackerman.

UNDERGRADUATE AWARDS

Departmental Citation: Amelia Danielle Whitson
AWG Outstanding Woman Student Award: Sara Gene Walkup
Ramsden Outreach Award: Sandra Desiree Fernando
GeoOlympics: Nick Odium, Scott Stromberg (tie)

DONATIONS TO THE DEPARTMENT

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 Exxon Mobil Foundation* §

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 Romey, William
 Thacher, Anson B.
 Wong, Florence

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NEWTON EMERGENCY FUND

Robertson, Craig

* Donation of \$1000 or more
 ** Donation of \$10,000 or more
 § Matching Funds

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Friends of Earth and Planetary Science Fund

Established in 2007 to solicit funds for emergency student aid, collegial activities in support of education and research as well as equipment and facilities upgrades; to help with costs for student activities such as field trips and the yearly Santa Barbara's Day event; to make a monetary award to the winner of the Departmental Citation; to support alumni outreach; to defray the costs of the weekly departmental Speaker's Program in which distinguished speakers from around the country are invited; and to assist in the acquisition of journals for the Earth Sciences Library and Map Collection. To donate, see <http://eps.berkeley.edu>

MEMORIAL FUNDS



Perry Byerly Fellowship Fund: Established in 1978 to honor the memory of Perry Byerly with a graduate fellowship in seismology. 2009-2010 recipients: Patrick Statz-Boyer, Scott French



Louderback Fund: Established in 1957 in honor of George D. Louderback to award outstanding students who are pursuing research, particularly in the field, in geology and paleontology. 2009-2010 EPS recipient: William Cassata



Thomas McEvelly Fellowship Fund: Established in 2002 to honor Professor Thomas V. McEvelly with a graduate fellowship in seismology.



Charles Meyer Fellowship Fund: Established in 1980 to honor Professor Charles Meyer by awarding a graduate fellowship in the area of integrated field and laboratory studies of ore, mineral, and rock-forming processes. 2009-2010 recipient: Ian Rose

Ralph Newton Emergency Fund: Established in 1994 in memory of Ralph Newton to provide emergency funds to graduate students.

Milton B. Smith Memorial Fund: Established in 2002 in honor of Professor Clyde Wahrhaftig by the estate of Dr. Milton B. Smith, B.A. 1936, Geology. The fund provides financial assistance to undergraduate students.



Don Tocher Memorial Fellowship Fund: Established in 1979 to honor the memory of Don Tocher with a graduate fellowship in seismology.



Francis J. Turner Fellowship Fund: Established in 1986 to honor the memory of Professor Francis Turner with a graduate fellowship in geology. 2009-2010 recipient: Pam Kaercher

ENDOWED FUNDS

Garniss H. Curtis Endowed Chair: Established in 2004 in honor of Garniss' contributions to science and to UC Berkeley.

John E. and Dorothy G. Kilkenny Earth Science Fund: This Fund will be used at the Chair's discretion to ensure the vitality of the department's Speakers Program.

Esper S. Larsen, Jr. Research Fund: Formally established on October 31, 1989. The proceeds of an endowment left to the University by Eva A. Larsen are used to support new research in the fields of geology, mineralogy and petrology. 2009-2010 recipients were:

- Don Depaolo: Understanding Molecular Transport Processes in High Temperature Petrologic Systems using Ca and Mg Isotopes
- Lynn Ingram: A Stable Isotope Record of Holocene Climate Change from Big Soda Lake, Nevada
- Michael Manga: Magma mixing and mobilization at Mount Lassen, CA

Ramsden Scholarships: Established in 1994 to support undergraduates who have expressed an interest in preparing for careers in the geosciences. In 2009-10 the Fund awarded \$8,500 in financial aid to undergraduate students and an additional \$6,500 to undergraduates for the following research projects:

- Magali Barba: Earthquake Early Warning Demonstration Tool
- Julia Hassen: Stable isotope analysis in mantis shrimp
- Juliana Spector: Research on local solutions to the effects of climate change
- Adam Zok: Supraglacial meltwater streams in the Juneau Icefield, AK

Richards Family Graduate Support Fund: Established in 2008 to support high-achieving graduate students with financial need in the Department of Earth & Planetary Science.

Graduate Student Field Support Fund: Established in 2008 to support, at the discretion of the department chair or graduate adviser, field work for earth science graduate students within the Department of Earth and Planetary Science. 2009-2010 recipient: Leif Karlstrom

Earth Science Scholarship Fund
For graduate fellowships, undergraduate stipends, honorary awards. 2009-2010 recipient: Adam Zok, Mendenhall glacier summer research

Scenes from the barbeque that greets incoming students each fall. *Photos by Margie Winn*



Imke de Pater, Raymond Jeanloz and alum Abby Kavner (Ph.D., 1997).



Catherine Pauling and Don DePaolo.



First-year grad student Andrea Chiang (left) with new graduate exchange student Ana Isabel Martinez-Poza.



Third-year students Jane (Waruntorn) Kanitpanyacharoen (left) and Shan Dou.

Views from the Field

Photo by Adam Zok



EPS Grad student Leif Karlstrom rappelling down to a stream in order to install a temperature logger.

Photo by Colin Amos



Postdoctoral researcher Rebecca Carey giving a field volcanology lecture to EPS 39 students atop Red Cone, a young basaltic cinder cone near Mammoth Lakes, CA

photo by Amanda Thomas



Max Rudolph and Michael Manga hiking up the north flank of Lassen Peak to analyze pumice characteristics as a function of distance from the vent and to look at size and shape distributions of mafic enclaves.

photo by Amanda Thomas



Grad students (left to right) Ian Rose, Edwin Kite and Max Rudolph on top of Cinder Cone in Lassen National Park. Lassen Peak in the distance.

photo by Michael Manga



Graduate student Max Rudolph (left) measuring gas flux at a spring, and Michael Manga measuring temperature at a mud pot, both near Calipatria, CA, the southeastern edge of the Salton Sea. These features are driven by CO₂ degassing. The springs and mudpots responded to the M7.2 El Major-Cucapah earthquake of April 4, 2010, by increasing their discharge (Rudolph and Manga, JGR in press).

photo by Max Rudolph



As part of the Keck HydroWatch project (led by Professor Inez Fung) being conducted at the Angelo Coast Range Reserve on the South Fork Eel River, graduate student Daniella Rempe is descending from high in the canopy after having collected samples of Douglas Fir needles for water isotope analysis. This project is exploring how rock moisture (water in the underlying fractured bedrock) may play a crucial role in providing water to forests during droughts and how the transpired moisture, in turn, affects climate processes.



Photo by Bill Dietrich