# *Earth and Planetary Sciences at UC Santa Cruz*

**Fall 2010**

**Summer Field 2010**

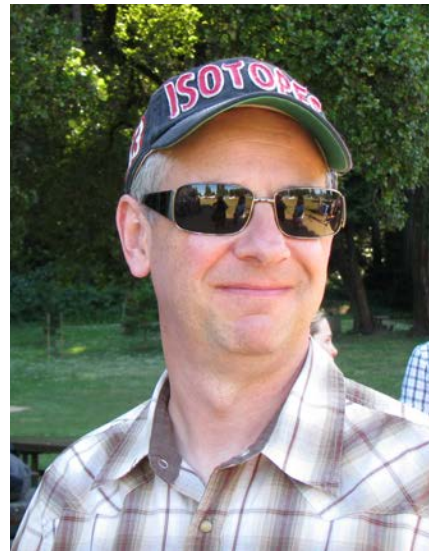
# Earth and Planetary Sciences at UC Santa Cruz

Fall 2010

Table of contents



## Chair's Welcome



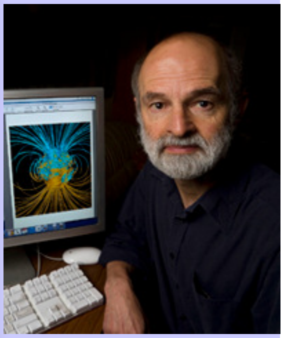
Dear Alumni and other friends:

Overall, the past year has been a good one for the Earth and Planetary Sciences Department. The department received external recognition of the growing strength of its research and teaching programs. Depending on how you crunched the numbers, UCSC ranked between 10th and 20th nationally in the long awaited review of graduate programs by the National Research Council (*see page 17*). This result is in line with the more subjective ranking done by the US News and World Report in 2010, which placed the department 13th in the nation. During its formal external review by colleagues from UCLA, Brown, and Scripps, the department was viewed as "on the rise" and received a clean bill of health. Faculty continued to receive major honors, including Gary Glatzmaier (elected to the National Academy of Sciences and the American Academy of Arts & Sciences), Thorne Lay (elected a fellow of the American Association for the Advancement of Science), Slawek Tulaczyk (elected a fellow of the Geological Society of America), and Gary Griggs (elected a fellow of the California Academy of Sciences). Our undergraduate major continues to grow, with over 50 graduates last year, and likely many more (~90) this year. As you might expect, our popularity is beginning to strain our capacity (e.g., 110B, our version of mineralogy, had ~80 students last year), but we manage to cope. Budget cuts have impacted the department in a number of ways (cuts to staffing and in the number of TAs) and the tuition increases over the past two years have been a strain on students. Nonetheless, the UC system, and UCSC in particular, still offer an incredible education for much less than our competitors (public and private) around the nation.

Finally, the department continues to experience faculty turnover. Ian Garrick-Bethell, our newest planetary scientist, arrived in July (*see page 4*). And after 38 years of distinguished teaching and research at UCSC, Jim Gill retired in July 2010. We had a celebration in June, following on a research symposium dedicated to Jim's career at the 2009 Goldschmidt Conference in Davos, Switzerland. Jim plans to remain active in research for the near future (he has several active grants), he just won't have to teach or deal with service. Not a bad deal, actually.

We look forward to seeing you at the Thirsty Bear on Tuesday December 14 in San Francisco, or in Santa Cruz at any time.

*Paul Koch, chair*



Gary Glatzmaier

Darcy Ogden

## Slug Web Corner

Science Sort Of (http://www.sciencesortof.com), a weekly podcast on science (Patrick Wheatley & Charlie Barnhart)

Amelia Lyons' blog on work in rural Uganda http://gypsyclicks.blogspot.com/

## Department News

**Gary Glatzmaier** was elected to the National Academy of Sciences and the American Academy of Arts and Sciences.
**Thorne Lay** was elected a fellow of the American Association for the Advancement of Science.
**Gary Griggs** was elected a fellow of the California Academy of Sciences.
**Slawek Tulaczyk** was elected a Fellow of the Geological Society of America.
**Slawek Tulaczyk** received the distinguished alumni award from Northern Illinois University
**Rob Coe** received the Outstanding Faculty Award for 2009-2010 from the Division of Physical and Biological Sciences.
**Patrick Chuang** received at Teaching Excellence Award from the northern California branch of Phi Beta Kappa.

## Alum News

**Charlie Barnhart** (Ph.D. '10) is a postdoctoral researcher at the Global Climate and Energy Project at Stanford University.
**Mary Bannister** (BS '76) is Manager of the Pajaro Valley Water Management District
**Gabe Bowen** (Ph.D. '03) was promoted to associate professor with tenure at Purdue.
**Brenda Beitler Bowen** (B.S. '98, M.S. '00) is an assistant professor at Purdue.
**Darren Croteau** (BS '97) is a Senior Geologist at AMEC Geomatrix.
**Michael Clynne** (B.S. '76; Ph.D. '93), currently with the U.S.G.S., was elected a Fellow of the Geological Society of America.
**Brooke Crowley** (M.S. '05) is a postdoctoral researcher at the University of Toronto.
**Maya Elrick** (B.S. 1981), currently a professor at the Univ. of New Mexico, was elected a Fellow of the Geological Society of America.
**Jon Erskine** (MS '98) is a Senior Scientist with the Granite Rock company.
**Sarah Hall** (PhD '09) is an assistant professor at McGill University, Montreal.
**Samantha Hansen** (Ph.D. '07) is an assistant professor at the University of Alabama.
**Chris Hundemer** (BS '96) is Senior Project Geologist with Treadwell & Rollo.
**Christy Kennedy** (BS '00) is a Project Manager with RMC Water and Environment.
**Sora Kim** (Ph.D. '10) is a postdoctoral researcher at the University of Wyoming, working with **Mark Clementz** (Ph.D. '02).
**Kira Lawrence** (M.S. '03) is an assistant professor at Lafayette College.
**Amelia Lyons** (BS '05) is working for a clean water non-profit in Gulu, Uganda.
**Seth Newome** (Ph.D. '05) is a postdoctoral researcher at the University of Wyoming.
**Nancy McKeown** (PhD '09) is an instructor at Grant MacEwan university, Alberta
**Darcy Ogden** (PhD '08) has accepted a faculty position at UC San Diego.
**Scott Paterson** (Ph.D. '87), currently a professor at the Univ. of Southern California, was elected a Fellow of the Geological Society of America.
**Catherine Riihimaki** (Ph.D. '03) is an assistant professor of biology and environmental studies at Drew University.
**Christie Rowe** (PhD '07) will be joining the faculty at McGill University, Montreal
**Greg Stemler** (BS '04) is a Staff Geologist at AMEC Geomatrix.
**Kathryn Sullivan** (BS '73) received the Global Oceans Award from the Seymour Center.
**Michael Wells** (B.S. '81), currently a professor at the Univ. of Nevada, Las Vegas, was elected a Fellow of the Geological Society of America.
**Patrick Wheatley** (Ph.D. '10) is a Intelligence Community Postdoctoral Fellow at Lawrence Berkeley National Lab.
**Rebecca Wolff** (BS '00) is an Engineering Technician with the Santa Clara Valley Water District.

## New Faculty: Ian Garrick-Bethell

Ian Garrick-Bethell's research focuses on lunar geology and geophysics. He generally works in three different areas. The first is the quantitative interpretation of very long-wavelength processes on the Moon. For example, the topography and crustal thickness on the lunar farside is much greater than on the nearside, and Ian has recently showed that the shape of much of the farside can be described by a simple mathematical function. Working with Francis Nimmo, they have also showed that it is possible that early tidal processes played a role in determining the large-scale structure of the farside crust.

The second area Ian works in is lunar paleomagnetism. Presently, the Moon has no global magnetic field like the Earth's, but many 3 to 4 billion-year-old lunar samples from the Apollo missions have remanent magnetization, as measured by instruments in Earth laboratories. The possible origin of the magnetization may be an early dynamo that has since gone extinct, or brief, strong magnetic fields generated by large, ancient impacts. Ian uses laboratory instruments to study the detailed magnetic record in Apollo samples and determine whether or not the Moon once possessed a dynamo.

The third area Ian works in is the interpretation of strong crustal magnetic anomalies on the Moon measured from orbit. In 1959, the Soviet Luna-2 spacecraft became the first object to impact the Moon. This mission carried with it a magnetometer that demonstrated the Moon has no global magnetic field. However, subsequently, numerous small-scale crustal magnetic anomalies have been discovered by NASA spacecraft that have orbited the Moon. The origins of these anomalies are unknown, but like the magnetized samples, include either magnetization of cooling rock in a dynamo field, or a process related to impacts. Interestingly, some of these magnetic anomalies are correlated with bright patches of soil on the surface, suggesting the magnetic field may be acting like a mini-magnetosphere, and keeping the solar wind (a darkening agent on planetary surfaces) from reaching the surface. Ian uses a number of datasets to interpret these unusual features and model their formation.

Ian is also working with NASA Ames Research Center to develop a robotic mission to the Moon using a complete, independent spacecraft no larger than a beach ball. The spacecraft would measure lunar magnetic fields and solar wind particle fluxes, and takes advantage of recent advances in the miniaturization of spacecraft subsystems. One goal is to demonstrate that small, meaningful planetary science missions can be accomplished at a cost much lower than traditional planetary science missions.

Ian received a BA in Physics from Wesleyan University in 2002, and an MS in Aeronautics and Astronautics from MIT in 2004. While at MIT, he developed several new robotic planetary science mission architectures, but eventually became more interested in basic planetary science. He defended his PhD in Planetary Science at MIT in December of 2008, focusing on lunar geophysics. He was a postdoc at Brown University until July of 2010, where he studied lunar crustal magnetic anomalies, the formation of large lunar impact craters, and the structure of the lunar farside crust. In July he started working full-time at UCSC.

Christie received her undergrad degree from Smith College in 2000 and her PhD in 2007 from UCSC., where she worked with Casey Moore on accretionary prisms in Alaska. She then took a teaching position at the University of Cape Town, South Africa, and is now a MARGINS post-doc at UCSC. She'll be starting a faculty position at McGill University in Canada in 2011.

# Fault Process Studies in Namibia

## By Christie Rowe (PhD 2007)

My passion is understanding faults: How they develop, cutting through solid rock, how they evolve, growing and changing as they slip, and especially how they generate earthquakes. I'm a field geologist and most of my studies focus on ancient faults, which have gone extinct and been passively exposed by erosion to the surface of the earth. This is the best way to get a window into the rock damage at depth of 10 or 20 km in the crust: the earthquake source. This approach is somewhat limited in that any given fault preserves a time-integrated record of every depth and temperature and deformation it has experienced, and it's hard to peel back every layer of the rock record to understand individual events. It has advantages as well - I can measure the exact size of earthquake-generating faults, for example, which seismology cannot resolve when studying modern earthquake waves. What I gain in spatial resolution by studying fault structures directly, I also compliment by collaboration with colleagues from other fields who use different methods to study earthquakes. I started this type of work on Kodiak Island, Alaska while doing my PhD with Casey Moore, studying faults from a 60 million year old subduction thrust. We discovered a previously unknown type of rock that forms on faults during earthquakes, by a uniquely seismic process of fracturing and flash heating. Subduction zones are not the only important setting where earthquakes occur. So when I joined the faculty at University of Cape Town in 2006 I was keen to explore the arid environments of southwestern Africa for more ancient faults that would provide windows into the earthquake source.

I started working in the Naukluft Mountains of central Namibia in 2008 with collaborators from University of Namibia (Windhoek) and Stellenbosch University. in South Africa. My colleagues' goal was to use isotopic tracers to map the groundwater use in this growing tourist region and determine whether recharge to the aquifers could keep up with increased demand. They asked me to join the project to map some of the ancient faults which now form subsurface pathways and/or barriers to groundwater flow.

**The Naukluft River (normally dry) after we got 5cm of rain in under 2 hours**

You would not have to be a hydrogeologist to suspect that rainfall is probably not keeping up with groundwater use in the region. Except in shady steep-walled canyons ("kloof/ kloove" in Afrikaans) there is no running water and no green vegetation for about 11 months of the year. The air is incredibly dry and daytime temperatures are often over 40°C. Most of the land surface is barren rock with a thin layer of gravelly regolith. In other words, the entire mountain range is a field geologist's dream: nearly 100% rock exposure! The rocks are shallow marine sediments: carbonates, quartz arenites and shales which were deposited in the Neoproterozoic to Cambrian – pretty similar to the stratigraphy of the Poleta Formation (very familiar to UCSC field camp students).

The Naukluft Mountains are all that's left

# Fault Process Studies in Namibia, continued

**" . . . the entire mountain range is a field geologist's dream: nearly 100% rock exposure!"**

**Hard at work**

of the frontal thrust belt of a major collision, when the Kalahari Craton subducted under the Congo Craton to the north during the formation of Gondwana 500 million years ago. This continental collision must have resembled the Himalaya of today, with a huge mountain range and intense metamorphism in the core, and folded/faulted shallow marine sediments of the foreland basin thrusting over the down-going plate. The big thrust faults, active at shallow levels (5-10 km in the crust) are very active and can produce large earthquakes.

**The Naukluft thrust fault (blue limestone footwall, orange dolomite hanging wall).**

The Naukluft Thrust itself is easy to see – the fault surface has been altered to dolomite and it makes a thick orange layer of fault rock that cuts across the landscape like a knife. We've mapped ramps, duplexes, off-fault damage, granular injections, and a whole range of cool structural features that are rarely exposed on this scale or in large faults. We're using these features to estimate stresses on the fault, in particular the high fluid pressures in the fault that would have been necessary to drive fault gouge into injection cracks. Some surprising minerals in the dolomite gouge may suggest $CO_2$-brine solutions existed for short periods of time during fault activity. If seismic slip is responsible for frictionally heating up the carbonate rocks, they would reach a dissociation temperature and outgas hot $CO_2$ instead of melting like silicates. A sudden burst of hot $CO_2$ from the rock would also contribute to transiently high fluid pressures which could explain the injections we see. So we're investigating whether we can use this mineralogy and texture as an indicator of seismic slip.

**Wildebeest standing between me and the fault outcrop. I stared `em down.**

I'm currently recruiting graduate students to work in Namibia on this fault system – so if you know a good candidate who loves field work, can live on kudu steak and hard water and generally look after him/herself, and has a solid background in structure and in chemistry, send them my way.

**Rain cloud moving across the red sand plains of the Namib Desert.**

Saffia Hossainzadeh is beginning her second year in the PhD program here in the EPS Department. She came from the University of Chicago, where she obtained a B.A. in Physics in '09.

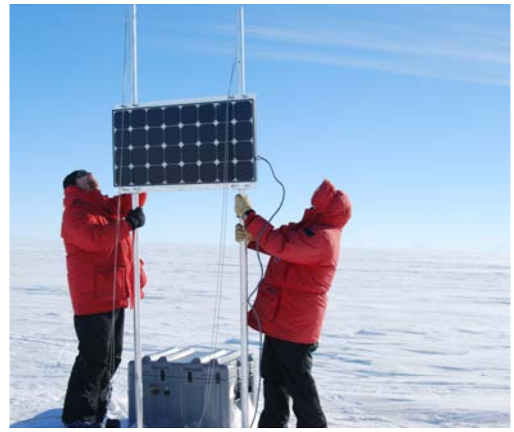
# Researching in Antarctica

## By Saffia Hossainzadeh

It is incumbent upon all good scientists to keep a humbled state of mind when studying Earth's natural processes. Sometimes, the most important discoveries are made while the scientist is performing the most mundane tasks, when she least expects any 'interesting' results. Antarctica's burgeoning and amorphous subglacial lake population was discovered in this way. Scientists must also humbly remember that important scientific discoveries require patience. In fact, discoveries are more often unraveled in a piece-by-piece fashion, to the constant backdrop of observation, and a willingness to challenge and push the borders of accepted opinion. Both of these modes of scientific progress -- patient, step-by-step deliberation and creative scrutiny leading to an unexpected breakthrough -- result in a renewal of excitement in the scientific community. These two modes of scientific thinking were present when I was given the opportunity to conduct field work in one of the most remote and unknown regions on Earth – Antarctica.

As part of Professor Slawek Tulaczyk's international research team, during the austral summer of 2008 we were based on the Whillans Ice Stream (84°S, 150-158°W), one of several areas of fast ice flow in West Antarctica. Our field camp came into existence in one afternoon and disappeared just as quickly at the end of our field season four weeks later. We brought everything we needed in two flights. Instruments like seismometers, hot water drills, and other tools as well as necessary survival items like food and tents fit into less than 10,000 pounds – one of the smallest, lightest remote field parties. We were going to be 'doing science' for four weeks and were expected to be self-sufficient since the nearest staffed base was over 300 miles away.

Since we only had a finite amount of



**Setting up solar panels**

time to undertake the necessary work to achieve our goals, we set to work immediately. GPS stations are scattered along the ice stream and need to be maintained so they could withstand another year of unforeseen storms and a dark lengthy winter. We were in charge of performing some of this maintenance – we raised the solar panels and brought the GPS devices and wiring to ground level so that they remain within easy digging reach for the next year's team. The GPS stations track precise positions along the Whillans Ice Stream, which are used to determine the ice stream's velocity – which is about 400 meters per year and decelerating in recent years. We hope that by studying this glacier, we may gain insight into how an ice stream can shut off and on again in multiple-decade timescales.

A second avenue of research that took place during our time in the field was to study the stick-slip motion by placing passive seismometers on Whillans' Ice Stream. Again, this research provides data needed to study how the ice streams move with mulstiple active systems in place. Both of these research areas build on decades of previous observation and scientific thought. The improvement of existing theories always requires a toler-

*Continued on p. 10*

Noah received his BA in Geology from Carleton College in 1999. During college, he thru-hiked the ~2100 mile Appalachian trail. Noah entered graduate school at the University of Washington in 2001, where he completed a PhD in 2007. Noah was a post-doctoral researcher at both Cornell University and Berkeley, before joining the UCSC faculty in 2009.

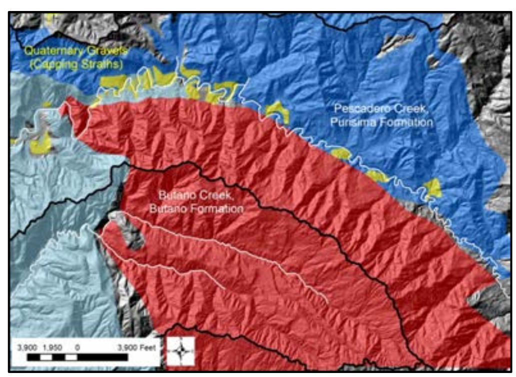
## Whither shall I wander? Trying to understand why a river does what it does. By Noah Finnegan

In our current state of information saturation, it is hard to imagine that large portions of the country were literally terra incognita as recently as the 1890's. However, this observation helps explain the great excitement that the first topographic surveys of the late 19th century inspired among practitioners of the burgeoning field of geomorphology. One in particular, William Morris Davis, had recently developed his theory of the "Geographic Cycle," and hunted for evidence in support of his "Cycle of Erosion" at the time of publication of the first USGS topographic maps.

Strongly influenced by Darwin, Davis sought an encompassing theory for topography akin to the theory of Natural Selection. The "Geographic Cycle" or "Cycle of Erosion" posited that after tectonic uplift, topography undergoes an evolution from youth through maturity, and that at each stage along this path characteristic landforms emerge (for example, v-shaped river gorges evolve to be broad, low gradient floodplains in wide valleys). The key implication for geologists of Davis' theory is that the form of a landscape reflects its age. Although most geomorphologists have subsequently discarded Davis' ideas in favor of those of his contemporary, Grove Karl Gilbert, who argued that landscape form reflects process not age, Davis' ideas nevertheless continue to enjoy favor among many within the greater Earth Science community.

Undoubtedly, the most popular of Davis' ideas came after he viewed for the first time newly created topographic maps of the Osage River in central Missouri in 1893 and saw, what to him, was clear evidence for his Geographic Cycle: river meanders carved in bedrock canyons. Writing in an 1893 *Science* article, Davis articulated the idea, now repeated in virtually all introductory geology textbooks, that meanders in river canyons result when a pre-existing meandering alluvial river channel slices like a cookie cutter through an uplifting bedrock mass, thereby preserving a vestige of the river's primordial state in the valley morphology. A brief survey of the geologic literature suggests that Davis' original idea is alive and well among professional geologists. And why not? Rocks are, after all, hard. Davis' idea is grounded in the intuitively appealing idea that bedrock on the bank of a river must present a far more formidable obstacle to bank erosion than the sand and gravel that commonly comprise alluvial channel banks.

Or does it? A century of subsequent work has in fact revealed abundant evidence (for instance, bedrock meander cutoffs) that rivers do in fact meander in rock. That said, until now surprisingly little was known about how this process actually works. As it happens, the Santa Cruz mountains in the vicinity of UCSC provide a wonderful natural experiment that has guided myself and my graduate students to a better understanding of the mechanics of river meandering in bedrock, and in particular, its intrinsic connection to sedimentary petrology.




**1. Simplified geologic map draped on a shaded relief image of the Pescadero and Butano Creek watersheds. Rivers are in white, watershed boundaries in black.**

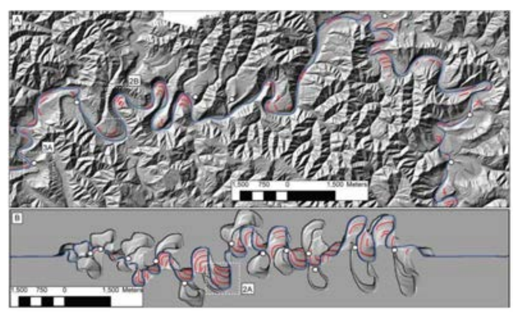
“ . . meandering bedrock channels are active and dynamically evolving, not fossil remnants of a bygone landscape.”

## Why a river does what it does (continued)

Butano Creek and Pescadero Creek lie approximately 45 km northwest of Santa Cruz, CA (Figure 1). Whereas Pescadero Creek traverses mudstones and clay-rich siltstones of the Purisima Formation, Butano Creek is largely contained within the sandstones of the Butano Formation. During the summer, when our local rivers dry down and expose channel walls that were underwater during the winter, clay in the Purisima formation contracts and the rock fractures above the low water line along Pescadero Creek (Figure 2). Because there is minimal clay in the Butano Formation, this process does not occur in the adjacent Butano Creek. Interestingly, these small differences in sedimentary petrology and hence fracture mechanics appear to exert a large control on the dynamics of these two channels. Pescadero Creek meanders extensively, whereas Butano Creek is essential straight as an arrow (Figure 1). Experiments performed in the field by UCSC geomorphology graduate student Kerri Johnson indicate a possible explanation. The highly fractured Purisma formation can be eroded simply with a strong water gun, under stresses comparable to a river at flood. This suggests that the fractured mudstone behaves analogously to the loosely aggregated materials that make up an alluvial river bank. By contrast, the Butano formation does not yield to

**2. Fractured mudstone along the wall of Pescadero Creek, pencil for scale.**

flowing water. Thus meandering bedrock channels are active and dynamically evolving, not fossil remnants of a bygone landscape, as Davis first envisioned. This dynamism has some intriguing consequences for how we interpret the topographic record in river canyons. In many actively incising river canyons, such as Pescadero Creek’s, river-worn bedrock terraces (known as “strath terraces”) occur tens to hundreds of meters above the active channel and often extend discontinuously for kilometers along the river. Bedrock terrace creation and abandonment requires alternating periods of dominantly lateral and dominantly vertical incision in a river, and explanations for this oscillatory behavior generally appeal to variation in tectonic uplift rate or in climate over time. However, active meandering also imparts a rhythm to a river as meanders grow, eventually cutoff, and form anew.



**3. A) Shaded relief image of the Smith River, Oregon, a stunning example of a meandering bedrock channel. B) Shaded relief image of numerical model output. In both images, bedrock meander cutoffs are identified by white dots, and bedrock terrace levels with red lines.**

To explore the consequences of meander loop evolution and cutoff on terrace development, I recently combined an existing model for meander evolution with an existing model for river incision into bedrock. A surprising outcome of this effort (Figure 3) is that bedrock terraces in river canyons, commonly thought to

## Why a river does what it does (continued)

form from climatic or tectonic perturbations to rivers, emerge spontaneously because of the dynamics of meandering. During meander growth, terraces form as a river's gradient decreases and its rate of vertical incision decays. Alternatively, following a meander cutoff, a section of the river is excised and a waterfall is created, thereby locally increasing the rate of vertical incision and propagating this increase upstream.

Belts of clastic sedimentary rocks, where strath terraces and bedrock river meanders are commonly observed, comprise wide swaths of most active mountain ranges on Earth. My work has shown that instabilities that are apparently inherent to these meandering channels causes them to develop rhythmic behavior that could be easily mistaken for a climatic influence. Disentangling such "autogenic" behavior from the true influence of varying climate and tectonics in California coastal rivers will undoubtedly keep my group occupied for years to come, that is if we don't succumb to Poison Oak first.

**Annual Alumni Event at Fall AGU**

**Tuesday, December 14, 2010**
**Thirsty Bear Brewing Company**
**661 Howard Street**
**San Francisco, CA 94105**
**http://www.thirstybear.com/**

## Antarctica (continued)

ance for incremental progress, and I was happy to help supply the scientific community with data that would further existing theory.

A third focus of our research was on the subglacial lakes in the region, which fill and drain in a rapid couple-year timescale. We laid out active seismic lines to image the bed layers and depth of water in this morphing basin of water 700 meters below the ice. Subglacial lakes and their link with basal water pathways is poorly understood, and their interaction beneath the continent of ice and their effect on the entire ice stream system is a new area of research. Thus, any data is useful data, and although we weren't part of the initial discovery of these numerous subglacial lakes (which was due to remote sensing), I felt the excitement of being part of a team bringing back early and unique data which would allow us a glimpse of Earth's newest secret – a dynamic body of water hidden under the ice.

In Antarctica, I participated in data collection in three research areas that are evolving differently based on their scientific maturity. Some are at the stage where data collection further tweaks the existing theory of a phenomenon whereas for other scientific questions, data collection that will allow researchers to simply observe the process, where not much theoretical work has been done, is still required. The dedication and joy I witnessed by fellow scientists and myself doing field work in Antarctica was strong in either case.

Which way up?

Jim Zachos in a contemplative moment at the Paleocene-Eocene boundary, New Zealand

## Degrees and Awards: Commencement 2010

BS/BA

Elena Amador
Julia Avila
Carlos Bazan***
Tyler Boyes*
Ashley Campbell
Renee Carmel
Annika Chase
Thomas Czabaranek
Seth Edman
Richard Ednie
Chris Edwards
Jasmine Eisner
Chris Gallagher
Jon Gamble
Diego Martin Gonzalez
Harrison Gray
Godwin Holgado
Dominic Horath**
Brett Hydeman
Daria Isupov
Patrick Kao
Amy Kaskowitz
Rachael Klier
Jake Kramarz
Max Kruzic
Kathryn Kynett
Lia Lajoie**
Charles Lewis
Stephen Lindley
Aviva Maine
Kayla Martin**
Nicolas Massetani
Ernesto Matal Sol*
Chloe Merz
Sara Meyer
Alex Morgan
Alicia Muirhead**/***
Emily Nelson
Matthew Panconi
Kyla Plumlee
Casandra Pritchard*/***
Matthew Rohrbach
Elizabeth Rose
Alex Rosenthal*
Samuel Saxe
Thomas Smart*
Devin Stewart
Brenna Sullivan*
Jessica Tibor
Paul Tran
Nathan Unangst*
Natasha Vokhshoori*
Kevin Walker
Michael Ward
Trevor Willits
Denise Wong
Jared Wong
Jared Zitron

* Honors

** Highest Honors

*** Thesis Honors

**Undergraduate Awards**

*Kathryn D. Sullivan scholarship*
Alicia Muirhead
*Holly Day Barnett Memorial Grant*
Kayla Martin
*Association of Women Geologists Outstanding Woman Geoscientist and EPS Outstanding Senior*
Lia Lajoie
*Santa Clara Valley Gem & Mineral Society Scholarship*
Thomas Smart
*Weber-Holt Grants*
Chris Gallagher, Harrison Gray, Shane Keefauver, Gregory Larson, Sarah Overton, Alex Rosenthal, Elena Sipe, Evan Wolf
*NSF Graduate Research Fellowship*
Alicia Muirhead

**Graduate Awards**

*Waters Award*
Erinna Chen & Jake Walter
*UCSC Sabbatical Fellowship*
Melanie Michalak
*Graduate Research Dean's Prize*
Heidi Stauffer
*Campus-wide outstanding TA*
Sora Kim
*Departmental outstanding TA*
Sam Johnstone
*Chevron Fellowships*
Yaofeng He & Sam Johnstone
*Earth & Planetary Science Fellowships*
David Finn & Melanie Michalak
*NASA Earth System Science Fellowship*
Ken Mankoff
*Outstanding student research award, GSA Structure & Tectonics section*
Melanie Michalak

Alicia Muirhead (left), Nancy McKeown (next), Elena Amador (far right) and colleagues during the SETI summer school

Elizabeth Crook in her field area

## Recent Graduate Degrees (2008-10)

**Travis O'Brien**, *How did Airborne Dust Affect North American Climate During the 1930's Dust Bowl?*, MS 2008

**Erin Doak**, *Volatile behavior during decompression from high pressures – Implications for degassing events during planetary tidal disruption*, MS 2008

**Michael Dueck**, *Tectonics and geologic hazards of quaternary faulting in northern Monterey Bay, California*, MS 2008

**Jun Cao**, *Toward a Wave-equation Based True-reflection Imaging*, Ph.D. 2008.

**Lindsey Chambers** (Bruesch), *Numerical Modeling of Saturn's Satellites and Ring System*, Ph.D. 2008.

**Alexander Hutko**, *Deep reflections: Imaging Reflectors in the Lowermost Mantle Using One-and Three-dimensional Stacking Techniques*, Ph.D. 2008.

**Darcy Ogden**, *Explosive Volcanic Eruptions: Does Vent Pressure Change Everything?* Ph.D. 2008.

**Kate Dallas**, *Anthropogenic Influences on Shoreline and Nearshore Evolution in the San Francisco Bay Coastal System,* MS 2009

**Tristan Rhodes**, *Measuring Recent Ice Mass Loss from the Margin of the Greenland Ice Sheet Using Aster-Derived Digital Elevation Models*, MS 2009

**Sarah Hall**, *Active Landscape Modification of the Western Central Andean Margin,* Ph.D. 2009

**Heather McCarren**, *Paleoceanographic Variability of Extreme Climates in the Early Paleocene,* Ph.D. 2009

**Catherine Plesko**, *Automated Feature Detection and Hydrocode Modeling of Impact-Related Structures on Mars,* Ph.D. 2009

**Chris Ruehl**, *Organic Aerosols--Where They Come From and Where They are Going (Some more Slowly Than Others),* Ph.D. 2009

**Jennifer Small**, *Observational Studies of the Microphysics and Dynamics of Warm Cumulus Clouds,* Ph.D. 2009

**Bridget Thrasher**, *Regional Climate Modeling Studies of Western North America under Early Eocene Conditions,* Ph.D. 2009

**Darren Tollstrup**, *Hotter than You'd Think: What Backarc Basalts Tell Us about the Fate of the Subducting Slabs,* Ph.D. 2009

**Erin Male**, *Detecting C02 Leaks Using Vegetation Reflectance Spectra: a Method of Monitoring Carbon Sequestration Fields Tested During the Controlled Shallow Subsurface CO2 Injections in Bozeman, Mt.* MS 2010

**Charles Barnhart**, *Geologic Phenomena Related to Water on Mars: Post-Impact Hydrothermal Systems, Impact Excavation and Valley Network Evolution,* Ph.D. 2010

**Nicholas Jarboe**, *The Steens Basalt of the Oregon Plateau: A Geomagnetic Polarity Reversal and the Age of the Columbia,* Ph.D. 2010

**Gary Hoffmann**, *Tectonics Processes and Submarine Flaws in the Bismarck Sea, Papua New Guinea,* Ph.D. 2010

**Sora Kim**, *Insights into shark ecology and physiology with stable isotope analysis,* Ph.D. 2010

**Peter Lippert**, *The Paleogene Latitude and Altitude of Central Tibet: Implications for the Cenozoic Tectonics and Climate,* Ph.D. 2010

**Nancy McKeown**, *Water on Ancient Mars: Forming the Phyllosilicates at Mawrth Vallis,* Ph.D. 2010

**Patrick Wheatley**, *Physiology and Ecology of Fossil Crocodilians,* Ph.D. 2010

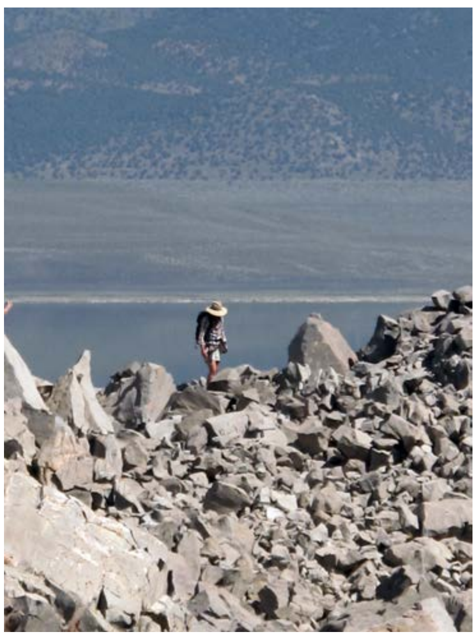
## Photo Page

Calla as a mandrill


Trilobite cake (with trace fossil)

Sue Schwartz, Hawaii

Sack race



Emily & Casey, pre-AGU field trip

Elena Sipe, Big Creek

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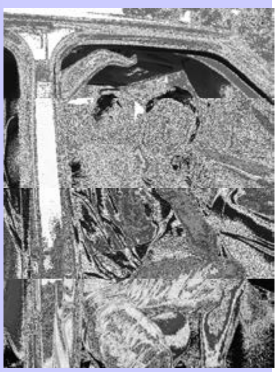


## Some notes on this year's graduating class (by Alicia Muirhead)

This year's graduating class is diverse and talented so in order to demonstrate the varied interests and accomplishments of this year's class I would like to share some of their memories and successes. Julia Avila worked extensively with Emily Brodsky last summer mapping old boreholes that could be used in the future for seismic studies. Her favorite part of her undergraduate career was summer field, especially the hot springs of SNARL and the river at Poleta, which I am sure many of you reading this can relate to. Julia will be going to graduate school at CSU Bakersfield for a masters in geology.

Harrison Gray, another accomplished senior, did research with Jeremy Hourigan while at UCSC and received the Weber-Holt Award. He fondly recalls a class with Noah Finnegan in which Noah declared, "My shirt's not pink, it's salmon." Harrison will be finishing his senior thesis and applying for graduate school in engineering geology this year.

Elena Amador did a planetary focus and a minor in astrophysics. She says that her greatest accomplishments were presenting at the Lunar and Planetary Science Conference for the past two years and working at the Johnson Space Center as part of the Lunar and Planetary Institute's Summer Intern Program studying mud volcanoes on Mars. She will be starting in a planetary science and astrobiology PhD program in the fall at the University of Washington in Seattle.

As for me, I will be attending the University of Colorado in Boulder for a PhD program in planetary geophysics this fall. My fondest memories from the E&PS department involve long study sessions in the science and engineering library, studying minerals in the halls of the D-wing, Monday night geology club meetings, and of course the annual department picnic. There are many other accomplished students that make up this year's graduating class, but hopefully the students I have written about will give you an idea of the on going success of graduates from our department. Finally, on behalf of myself and the graduating class, I would like to thank our professors, mentors, teaching assistants, and peers for the wonderful experiences and outstanding education we received at UC Santa Cruz. graduates, as well as younger classmen, to continue pursuing the field of Earth Science. The knowledge we have acquired provides the basis for an understanding of Earth's future and the need for careful management of its resources.

Sunset, Big Creek

## A Modest Proposal . . . From Jerry Weber

**UCSC Earth Sciences Alumni Raft Trip**
**The Green River – Desolation and Gray Canyons**
**Mid – Late August 2011**

Against my better judgment…I've decided that what we need is a late summer raft trip down one of my favorite river canyons – Deso-Gray. If you're interested in spending 8-9 days floating 84 miles through two wonderfully scenic canyons with 20-25 UCSC geologists, Ann Chase (former field camp cook) and Sue and me; then this is for you. The river is mellow (only 2-3 rapids are rated as 2.5 out of 5) with lots of riffles. If you don't know how to row a raft…I can teach you. I will try to get a put in date between **August 16th – 20.th** I will not be able to get a permit until mid May of 2011 – after which I will notify interested parties.

So…I'm willing to do the logistics and put this whole thing together and run the raft trip. All you have to do is get your personal gear together and meet me at the put in. I'll rent the rafts, inflatable kayaks, groover, life jackets and dry bags as needed, get the food lined up, the cook and deal with permits, etc. I will also make arrangements for the shuttling of vehicles from the put in to the take out. I've run this river at least 12 times.

The put in is at Sand Wash southwest of Vernal Utah. It is a bare bones camping area at the end of about 30+ miles of dirt road, with a resident ranger in a trailer and pit toilets – that's it. There is no fresh water available other than the river; bring at least a 2 day supply with you. The take out is just below Swaseys Rapid about 10 miles north of Green River, Utah (a short drive to a cold beer).

**Regional Geology & Stuff:** The trip begins in a broad, relatively shallow canyon cut into the Eocene Green River Formation (lake deposits). The canyon slowly deepens as we head down stream; and we move both laterally and vertically into the fluvial deposits of the Colton Formation of the Wasatch Group. As we float down stream the canyon narrows and deepens as we cross through the northward tilted Tavaputs Plateau in a canyon several thousand feet deep. At

**" I personally plan to do nothing more strenuous than popping open beer cans"**

## A modest proposal . . . (continued)

three fords rapids (about 25 miles from the take out) we emerge from the Roan Cliffs and drop down into the Mesa Verde Group of Cretaceous age. Two days later we will exit the plateau through the Book Cliffs into the lowland underlain by the Mancos Shale. At this point we are at the "take out," and our geologic journey is over.

The canyon is also rich in history, starting with the Fremont culture, which left its graffiti (Petroglyphs) scattered through the canyon. Powell floated the canyon in 1869 on his way down to the Colorado. Old abandoned ranches, one of which traded horses with Butch Cassidy's "wild bunch" are present at several areas. One of our many stops will be at Firewater Canyon, where we will have a short hike up to an abandoned stone house where "moonshine" was produced during Prohibition.

**Anticipated Costs**
I estimate that the cost for the 8 day raft trip including boats, groover, kitchen equipment, life jackets, dry bags and food will be $350 per person – it could be a bit more. To have your vehicle shuttled from the put in to the take out (trust me it's worth the money) will be $200 per vehicle. We can worry about car-pooling and all that crap later.

**Recreational Beverages**
Everyone should bring their own brand of poison. The river isn't very cold, it's about 70-72 ° and it keeps the beer just cold enough to make it palatable. **All beer must be in cans**. Hard stuff is fine, but keep it under control – no puking in the rafts.

**How much time should I allow?:**
If you are driving from the Santa Cruz area it will take two days, if you're willing to have one very long day. You need to arrive at Sand Wash on the afternoon **before** the day we put on the river. Put in the next day before noon. Eight or on the river (maybe one lay over day at Flat Canyon) – and we take out on the last day before noon. Drive home at your leisure. You should plan on a minimum of 12-13 days for the trip, and I suggest you take longer.

**General Rules:** All cooking, dish washing, loading and unloading of boats and other chores will be shared. We expect everyone to help as much as possible during the daily loading and unloading of boats and in de-rigging boats after the trip. I personally plan to do nothing more strenuous than popping open beer cans

**More Information**
Check the Deso-Gray website at the Bureau of Land Management for information on the area. Weather should be good, but there is always the possibility of wind and thunder storms. Although this is a whitewater trip, the rapids are all relatively small. However, you should realize that any trip of this sort poses some potential dangers - falls, burns, insect bites, animal bites, etc. Drunks could fall into the river and drown . We will be out of touch with civilization for a week. **The only way out of the canyon between the put-in and the take-out is to walk or by helicopter.** There aren't any conveniences, and help in a real emergency is a long way off in both time and distance.

I hope this brief note is sufficient to temp you to participate. Remember!! Neither the university nor I take any responsibility for your actions or what happens to you on this trip. This is an offer to set up a trip, not baby sit.

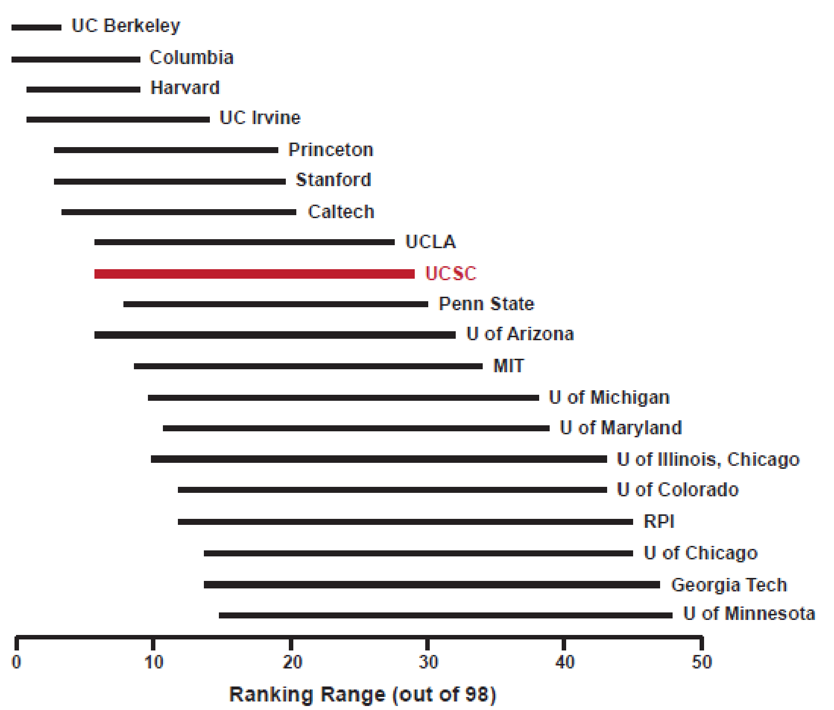
**Questions? Please contact me at:**
**Jerry Weber (831) 426 - 1367 or**
**jweber@pmc.ucsc.edu**
http://groups.google.com/group/es-raft-trip

## Department Rankings (by Paul Koch)

This year two rankings of U.S. Ph.D. programs were released that testified to the Department's rising prominence. The U.S. News & World Report conducts a survey of Earth scientists to gauge reputation. In this ranking, the Department was tied for 13th (along with Cornell, U. of Wisconsin, and U. of Washington). It had the second highest ranking among programs in the UC System (only Berkeley was higher). This was up from 19th in the 2006 ranking.

The National Research Council of the National Academy of Sciences also released their rankings of U.S. graduate programs. These rankings were based on data collected from departments in 2005 on a range of factors, such as publications, citations, funding, faculty awards, and student outcomes. Rather than produce a single set of rankings, the NRC generated a range of values, using weights for the factors derived from a survey of a large group of Earth scientists. Out of ~100 universities with similar programs, UCSC placed ~9th. This is a spectacular rise from our ranking of 24th by the NRC in 1995. Only three other public universities have a higher ranking than UCSC, and all are UC campuses (Berkeley, Irvine, and LA). This more data-driven assessment highlights the great impact of research conducted in the Department, as well as the success of our graduate students at landing excellent positions.

2010 NRC Rankings of Geological Science Ph.D. Programs




The figure considers programs in Geology, Geophysics, Environmental Geoscience and Planetary Science. Ranks for all such programs at a university are averaged to create a campus-wide rank.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Please use space below and continue on facing page. Let us know where you are and what you are up to!

May we publish your comments on the Earth and Planetary Sciences website under Alumni? ☐Yes ☐No
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### The Aaron & Elizabeth Waters Fund
This fund honors the founder of our department and his wife. The Waters Fund is a scholarship fund for grad students and is given as an annual award for the most meritorious Ph.D. thesis proposal (or two) of the year.

### The Gerald Weber & Suzanne Holt Fund
The Gerald Weber and Suzanne Holt Fund interest is currently used to provide summer field camp scholarships for meritorious students, support undergraduate students giving talks or poster sessions at national conferences, the Outstanding TA Award as nominated by students, and the annual Outstanding Undergraduate Award. It may also be used to support other kinds of special student projects.

### The Kathryn D. Sullivan Scholarship Fund
This fund honors astronaut Kathryn Sullivan, one of UCSC's most distinguished alumnae. Its aim is to enable upper-division undergraduates to take advantage of professional development opportunities (e.g. field research, attending conferences) and improve their understanding of environmental and policy issues.

### The Holly Day Barnett Fund
This fund is a tribute to undergraduate alumna Holly Day Barnett. Awardees (advanced undergraduates) have traits in common with Holly's: outdoor hobbies, leadership skills, and interests in environmental Earth Sciences.

### The J. Casey Moore Fund
This new fund (established in 2007) honors Emeritus Prof. Casey Moore. It supports targeted grants for independent research by graduate and undergraduate students.