Earth and Planetary Sciences at UC Santa Cruz

Fall 2013

2013 Summer Field Students

http://eps.ucsc.edu

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Fall 2013

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Chair's Welcome

Dear Alumni and Friends,

From a UC-wide budgetary perspective, this year's been pretty good—in lieu of the recent history of annual cuts, our department (and our campus) has had at least a status quo kind of year, and that's a relief. Things have gone well on other fronts: **Casey Moore** has continued his emeritus-awards tour, by being awarded fellowship in the American Geophysical Union; and PB Sci Dean **Paul Koch** became a Fellow of the California Academy of Sciences. And, among our spectacular alumni, **Kathryn Sullivan** (B.S. '73) rose to new heights as the new acting Director of the National Oceanic and Atmospheric Administration…Congratulations to Kathryn! It's also been a year of major initiatives by our faculty—as described in this newletter, **Slawek Tulaczyk** led a major drilling project of a subglacial lake in Antarctica (the WISSARD Project—Google it if you want more info!), using instruments designed and built in-house here at UCSC by our outstanding technical staff. **Emily Brodsky** (and a large supporting cast, including Casey) drilled into the Tohoku fault zone off of Japan to measure the frictional signature of that massive seismic event—and got temperature measurements across the fault zone *in situ*, beneath deep water and the overriding plate!

As is the case with all dynamic departments, we've had a few changes in the last year. We hired a new geochemist onto the faculty, **Terry Blackburn**---Terry's arriving this coming July from his post-doc at the Carnegie Institute, which followed his Ph.D. at MIT. Terry will take over our Keck isotopic lab while pursuing his work, which spans from probing the history of continental lithosphere, to figuring out the detailed chronology of what happened during the Permo-Triassic extinction (a recent first-authored cover article in *Science*!), to examining meteorites to constrain the earliest processes of chondrite formation in the solar system. On the flip side, **Erik Asphaug** has changed his status: although he has taken the Greeley Chair Professorship of Planetary Science at Arizona State, he still spends so much time in Santa Cruz (and in the Department) that he's now a Research Associate with us.

From the campus perspective, we are approaching the 50th anniversary of the founding of UCSC, and the campus' first Capital Campaign has just been announced, with a goal of raising $300 million for the campus. And, though it sounds large, much of that money will be raised a little at a time. Our Department itself is, in tandem with the Capital Campaign, working on enhancing our fundraising and alumni outreach—we convened our first alumni advisory committee in June, and received lots of fabulous advice. And it's in that area where we would vastly appreciate any support you can give to maintain the caliber of the educational experiences that our students can access. On p. 23, you'll find descriptions of some of the donor opportunities on which we're particularly focusing in the coming year. These include the Weber-Holt Fund, which provides scholarships for students attending field camp; the Casey Moore Fund, for which the first awards were just made to seed graduate student research opportunities in our Department; and the Earth Sciences Fund, which supports lots of general activities, not least of which is our annual get-together at the **Thirsty Bear** during AGU week in San Francisco.

And that brings up our invitation: we'd love to see you at our 12th (!!) annual alumni/friends/current folks' get-together at the Thirsty Bear ("San Francisco's first and only organic brewery") during AGU. It's a fantastic opportunity to see old friends and make new ones (and, needless to say, have some really good beer and snacks, too). It's **Tuesday, December 10th**, 6 – 8.30 p.m., 661 Howard Street, San Francisco—Hope to see you there!

Quentin Williams, Chair

Paul Koch

Kathy Sullivan

Casey Moore

Slug Web Corner

We are now on Facebook! Like us at **www.facebook.com/UcscEPS**

Department News

Casey Moore was made a Fellow of the American Geophysical Union.

Paul Koch was made a Fellow of the California Academy of Sciences.

Terry Blackburn was appointed as the newest member of faculty in the EPS department. Terry is an expert in high-precision geochronology and is currently finishing a post-doc at the Department of Terrestrial Magnetism at the Carnegie Institute of Washington.

Terry Blackburn

Alumni Awards

Kathryn D. Sullivan (BS, 1973) has been nominated to be the new Under Secretary for Oceans and Atmosphere and Administrator of the National Oceanic and Atmospheric Administration (NOAA), Department of Commerce

Rich Koehler (class of 1992) was elected Vice-Chair of the Alaska Seismic Hazards Safety Commission.

Vince Matthews (PhD 1973) was the General Chair of the 125th Annual Meeting of GSA this fall. He is also the 2014 recipient of AAPG's Pioneer Award, elected to Honorary Membership in the Association of American State Geologists and received the 2013 Exceptional Service Award from the Colorado Emergency Management Community.

John F. Childs (PhD, 1982) received the 2011 Tobacco Root Geological Society Award for Excellence in Geological Field Work.

Arrivals/Departures

Prof. **Erik Asphaug** is leaving UCSC for the warmer temperatures at Arizona State University. We wish him well.

Cathy Smith has returned to the department to cover for **Jennifer Fish**, who is on maternity leave.

Slug Science Round-up

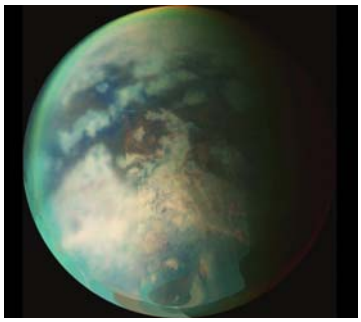
Giant insects' sway ended by birds

Giant insects (see picture) are recorded in the geological record every time that atmospheric oxygen levels became large enough to allow them to "breathe". That changed, however, once birds appeared. Prof. **Matthew Clapham** and grad student **Jered Kerr** studied the evolution of insect size with time, and suggested that giant insects became easy targets once birds evolved, vanishing from the geological record.

A 300 million-year old insect wing 8 inches long, compared with the largest present-day insect wing.

Geothermal power plants trigger earthquakes

An analysis of earthquakes by Prof. **Emily Brodsky** and grad student **Lia Lajoie** found a strong correlation between seismic activity and operations for production of geothermal power, which involve pumping water into and out of an underground reservoir. The area they investigated was the Salton Sea in Southern California (see picture on right).



Titan's stiff, weathered ice shell

Titan, an icy moon of Saturn, has a thick, rigid shell which is being eroded by winds. That conclusion was reached by Prof. **Francis Nimmo** and grad student **Doug Hemingway** based on gravity and topography data collected by NASA's *Cassini* spacecraft.

We hope to see you at the Thirsty Bear Brewing Company for our *12th Annual UCSC Earth & Planetary Sciences Alumni Event at Fall AGU!*

When? **Tuesday, December 10th, 2013**
from 6:00pm - 8:30pm

Where? **Thirsty Bear Brewing Company**
661 Howard Street, San Francisco, CA 94105
http://www.thirstybear.com/

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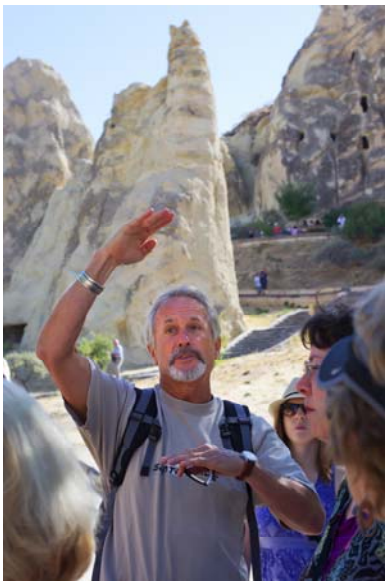
Slugs in the Field



Gary Griggs explaining the "fairy towers" of Cappadocia

Patrick Fulton (with beard) celebrating the successful retrieval of the temperature sensors deployed by the *Chikyu* for the JFAST project

Paul Koch taking time off from being Dean to examine seal carcases in Antarctica. A crabeater seal is shown below

Grant Rea-Downing and Ethan Brown in Bruneau Canyon, Idaho.

Nadine Quintana Krupinski staying in shape during an IODP cruise.

Grace Barchek, Dan Sampson and Marci Beitch in Antarctica as part of the WISSARD project (pp. 13-15)

Jim Gill, Judy Fierstein and colleagues at a volcanic crater on the border of China and North Korea.

Graduate Degrees, 2012-13

Kira Badyrka, Fall 2012 (MS)
"Brachiopod Paleoecology during Late Paleozoic Climate Change, Pennsylvanian -Early Permian, Bolivia"

Erinna Chen, Summer 2013 (PhD)
"Ocean tidal dissipation and its role in satellite evolution"

Karin Ohman, Fall 2012 (MS)
"Vulnerability of a subarctic barrier spit to global warming induced changes in storm surge and wave runup: Shaktoolik, Alaska"

Travis Orloff, Fall 2012 (PhD)
"Boulders cluster on Martian permafrost patterned ground"

Kathleen Usilov, Summer 2013 (MS)
"Regional changes to lake effect snow levels in New York state under projected future climate conditions"

Rui Yan, Summer 2013 (PhD)
"Angle-domain imaging condition and its applications to RTM, AVA analysis and true amplitude imaging"

Jered Kerr, Summer 2013 (MS)
"Taphonomic biases in the insect fossil record: Inconsistent preservation over geological time"

Lia Lajoie, Fall 2012 (MS)
"Seismic response to fluid injection and production in two Salton trough geothermal fields, Southern California"

Timothy Lambert, Fall 2012 (MS)
"Towards an understanding of phosphate $d^{18}O$ in the bones and scales of small pelagic fish"

Melanie Michalak, Summer 2013 (PhD)
"Cenozoic uplift of the Peruvian Andes: Insights from mineral chronometers"

Graduate Awards

CAMPUS-WIDE OUTSTANDING TA:
Mikael Witte

DEPARTMENTAL OUTSTANDING TA:
Priya Ganguli (Winner)
David Finn (Runner-Up)

HONORABLE MENTION DEPT OUTSTANDING TA:
Rhiannon Bezore
Alison Pfeiffer
Rachel Brown Reid

WATERS' AWARD:
Doug Hemingway
Alanna Lecher
Lingling Ye

ARCS FOUNDATION AWARD:
Rachel Brown Reid

SWITZER ENVIRONMENTAL FELLOWSHIP:
Priya Ganguli

LAWSON HYDROLOGY AWARD:
Sarah Beganskas
Allison Pfeiffer

J. CASEY MOORE FUND AWARD:
Tracey Conrad
Alex Nereson

NSF GRADUATE RESEACH FELLOWSHIPS:
Sarah Beganskas
Claire Masteller

NSF DIRECTORATE DOCTORAL DISSERTATION IMPROVEMENT GRANT:
Rachel Brown Reid

GEOL. SOC. AMERICA GRAD STUDENT RESEARCH GRANT:
Rachel Brown Reid

EXXONMOBIL GEOSCIENCE GRANT:
C. Grace Barcheck

Graduate Awards (cont'd)

ALEXANDER AND GERALDINE WANEK GRAD SCHOLARSHIP:
Alex Nereson

JOHN MASON CLARKE 1877 AMHERST COLLEGE FELLOWSHIP:
Sarah Beganskas

MILDRED E. MATHIAS GRADUATE STUDENT RESEARCH GRANT:
Priya Ganguli

CENTER FOR DARK ENERGY BIOSPHERE FELLOWSHIP:
Delphine Defforey

SIGMA XI RESEARCH SOCIETY GRANT IN AID OF RESEARCH:
C. Grace Barcheck

FRIENDS OF LONG MARINE LAB STUDENT RESEARCH AWARD:
Rhiannon Bezore
Tracey Conrad

Undergraduate Awards

HOLLY DAY BARNETT MEMORIAL GRANT

Jessica Johnston

MYERS TRUST AWARD:

Rachel Hohn

WEBER-HOLT GRANTS

Alicia Balster-Gee
Samuel Bold
Brian Cook
Sophie Foster
Rachel Hohn
Kyle Johnson
Patrick McCarthy
Cory Steinmetz
Keenan Takahashi

Undergraduate Degrees (BS/BA)

Brent Alexander Adam
Alicia Balster-Gee
Taylor Barrett
Chris Baker
Kimmy Robin Beckler
Samuel Edward Bold
Rick James Brooke
Elizabeth Brown
Brian B. Cook
Nakul Deshpande
Igor Dokic
Cooper Alexander Dressler*
Emily Clare Edwards*
Michael Eshom
Sophie Lee Foster
Gustavo Nelson Galan Hoffman
Omar Ulises Garcia
Derek Christopher Gill*
Bryan Arcady Groza
Ryan Harmon
Nicholas Robert Hawthorne
Kyle Johnson
Jessica Jane Johnston*
Kaitlyn Leigh Jones
David Mason
Blake McBride
Sean Donalee McDonald
Travis Mellett
Jordan Daniel Murphy
Krista Falcon Myers*
Tyler Nakamura**+
Jerrod Andrew Pena
Joshua Andrew Ramirez
Candice Marie Rebollo
Coral Lee Rudholm
Frederic Robert Trang
Walker Blackburn Weir
Emily Welk
Ben Yordduangjun

* Honors
** Highest Honors
+ Outstanding senior

Slug Interns Swarm the USGS

Hilde Schwartz

Since 1965, the National Association of Geoscience Teachers (NAGT) has co-sponsored a Co-operative Summer Field Training Program (CSFTP) with the US Geological Survey. This program places top students from over 120 summer field geology camps nationwide with scientific mentors at the USGS for two to five month-long internships. This is the longest continuously run internship program in earth sciences in the United States, and more than 2,200 students have participated since its incept. Some CSFTP participants continue working at the USGS post-internship, and many go on to obtain graduate degrees. Interns who become professional earth scientists typically maintain contact with their USGS mentors throughout their careers. The bottom line: this is a great opportunity for students.

Predictably, the CSFTP is highly competitive. Each fall, participating field camp instructors are invited to nominate between one and three of their best students from that year's summer field course (the number of nominees allowable varying with class enrollment). Nominees then apply to the program, and an academic panel matches applications to potential projects. Finally, USGS project scientists interview, rank and make the final selections of interns. Historically, the number of available summer internships has varied over orders of magnitude (~7 to ~150) in response to changing funding levels and research needs, but there has always been significantly more demand for internships than supply.

All of the above is prelude to some good news about our field geology undergraduates. At least 20 UCSC Earth Sciences majors have participated in the CSFTP since 1977, and our students have been particularly successful at competing for internships during the last decade. Consider the following statistics. Since 2004, 11 out of 301 CSFTP interns (from more than 120 field camps) have been UCSC graduates. Though we represent less than 1% of participating programs, our department has supplied 3.7% of recent interns. From 2004 – 2006, when less than 20 interns were placed annually nationwide, one UCSC student was chosen each year, and one or two of our majors has been selected for the program every year since 2008. UCSC interns have worked in field areas from Alaska to Colorado to the Salton Trough, on projects ranging from hydrogeologic mapping to luminescence dating to seismic imaging.

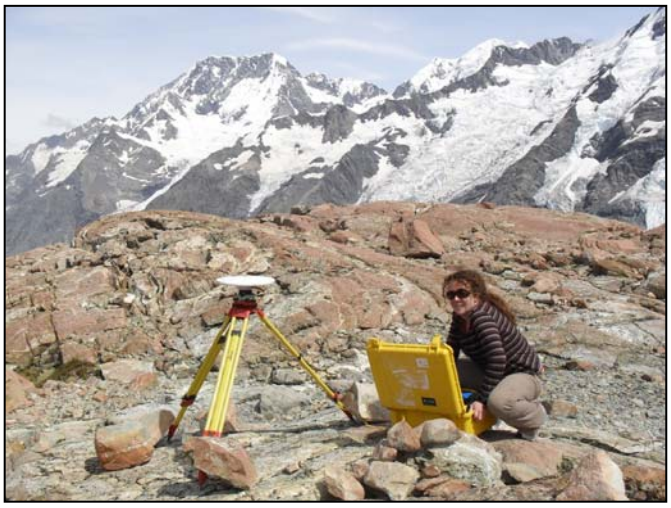
This year, two of 45 SDFTP interns (that's 4.4%!) are UCSC graduates. They are: Gabriel Matson (above), who worked with Dr. Victoria Langenheim (Menlo Park) on "Geophysical investigations of geothermal, mineral, and water resources and natural hazards in the western U.S., and Jonathan Ooms (below), who participated in a project involving emplacement, operation and maintenance of the National Seismic System, with mentor Dr. Alena Leeds (Golden, CO). Big congratulations to Gabe and Jonathan, and to all other Geoslugs who've participated in the CSFTP. To current Earth Sciences undergraduates, a heads-up: it really pays to work hard in 'Summer Field'!

2013 USGS intern (and 2012 UCSC Earth Sciences graduate) Gabe Matson, measuring gravity in the hills above San Luis Obispo for the Menlo Park Geophysical Unit.

2013 USGS intern (and 2013 UCSC Earth Sciences graduate) Jonathan Ooms (on left), completing a routine check on one of the ANSS "backbone" seismic stations in Idaho Springs Colorado (ISCO). The large yellow vaults hold a broadband seismometer (background) and data acquisition system (foreground). The station is located 400ft inside a former mine tunnel.

Tracking plate tectonics in real time

Laura Wallace (PhD 2002)



Laura Wallace doing campaign GPS work n the South Island, New Zealand

Ever since the day my 4th grade teacher taught our class about plate tectonics, it has always fascinated me. Of course at the time, I had no idea that I would eventually devote my career to studying tectonic deformation processes. In 1996, I had the good fortune to embark on a PhD in Earth Sciences at UCSC with Eli Silver. At the time, Eli was developing a project to use Global Positioning System (GPS) to track tectonic plate movements in Papua New Guinea (PNG). PNG is one of the most dynamic active tectonic settings on Earth, and the high rates of movement there (> 10 cm/yr in some places) make it an ideal location to use repeated GPS measurements at permanent survey benchmarks to reveal the distribution of active deformation there. That project formed a large component of my thesis, and I continue to use GPS to study a variety of tectonic deformation and faulting processes today, at locations around the western Pacific. Although GPS is one of the primary datasets that I use in my research, I also enjoy integrating GPS results with other geophysical and geological datasets to help answer fundamental questions about the driving mechanisms behind plate tectonics, and physical controls on fault slip behavior.

Following the completion of my PhD at UCSC in 2002, I took a research scientist position at GNS Science in Wellington, New Zealand. GNS is New Zealand's national geoscience research organization, similar to the USGS. The opportunity to work at GNS was a real career-defining move for me, as the GPS datasets available in New Zealand are world class, and I learned a huge amount from the large and talented group of geophysicists and geologists in New Zealand working on active plate boundary processes. Moreover, when I arrived in 2002, New Zealand was just starting to develop a continuously operating GPS (cGPS) network, and I landed just in time to play role in the design of the New Zealand cGPS network configuration. cGPS involves permanent installation of a GPS instrument that collects data continuously, over many years. cGPS has huge advantages as it enables monitoring of the GPS site position on a daily basis, compared with highly intermittent observations that are done using campaign-style (or survey mode) measurements like those we were doing in PNG. cGPS allows us to detect small changes in the motion of a GPS site in real time, and is incredibly useful for monitoring temporal variationns in fault slip processes.

A major focus of my research for the last ten years has been to use cGPS data to study a recently discovered form of fault slip called "slow slip events". Slow slip events are similar to earthquakes, in that they involve episodic, more rapid than normal slip along a fault. However, slow slip events take days to years to occur, while slip in an earthquake occurs in a matter of seconds. Slow slip events were first discovered almost 15 years ago by scientists in Canada, using cGPS at the Cascadia subduction

zone. Since that time, deployment of continuous GPS networks at subduction zone plate boundaries in Japan, Cascadia, New Zealand, Mexico, Costa Rica, and Alaska has led to the widespread documentation of slow slip, which now appears to be common to most subduction interface faults. Despite the widespread occurrence of slow slip events, scientists still do not fully understand the physical mechanisms causing them to occur. Investigation of slow slip events is also incredibly important for understanding the seismic hazard posed by subduction megathrusts. For example, in most locations, slow slip appears to occur along the transition from stick-slip (e.g., earthquake behavior) to steady, aseismic creep. Thus, the delineation of slow slip zones can help us to understand which portions of the subduction thrust could be more prone to slip in great earthquakes. Many scientists also think that stress changes due to slow slip events could trigger large subduction thrust earthquakes. In fact, scientists in Japan have found evidence from seafloor pressure sensors and seismological data that a slow slip event occurred in the weeks preceding the Giant Mw ~9.0 earthquake at the Japan Trench in 2011.

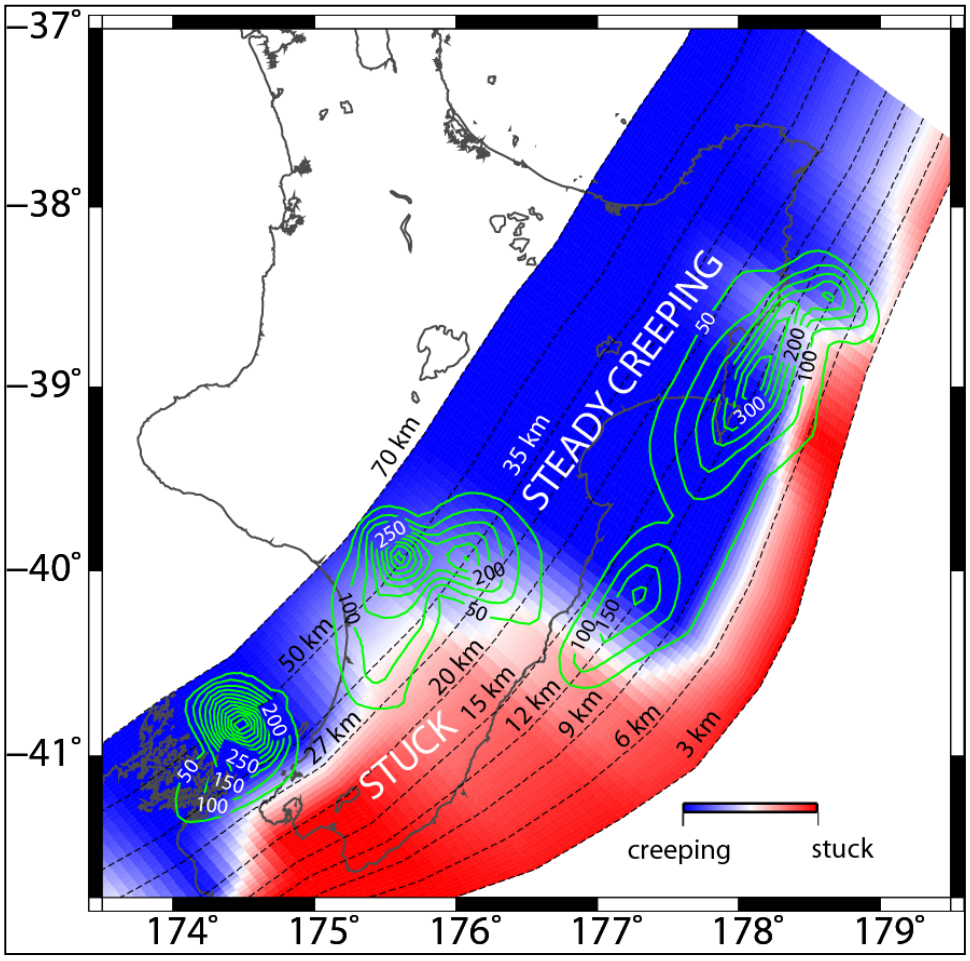
New Zealand is an exciting place to study slow slip processes because the North Island of New Zealand overlies a huge depth range of the subduction megathrust fault, enabling land-based GPS studies of slip processes on a large portion of the megathrust. Moreover, the variety of slow slip events in New Zealand is particularly astonishing. At the southern Hikurangi margin, deep (30-50 km), long-lived (1-2 years), large (equivalent to an Mw 7.0 earthquake) slow slip events occur, while at northern Hikurangi slow slip events are shallower (<15 km depth), shorter (1-3 weeks), smaller (Mw ~6.5). Northern Hikurangi slow slip events are some of the shallowest SSEs documented anywhere in the world, occurring at 5-15 km beneath the Earth's surface, and it is possible that they propagate all the way to the seafloor at the Hikurangi Trench.

A continuous GPS site in the North Island, New Zealand that is part of the GeoNet cGPS network (www.geonet.org.nz)

The shallow depth of slow slip events at North Hikurangi has inspired a large group of us to develop a series of proposals for the International Ocean Discovery Program (IODP) to actually drill into the area of the subduction interface where shallow slow slip occurs offshore New Zealand, at ~5.5 km below the seafloor. Doing this would allow us to answer a number of questions about what causes SSEs, which is currently a mystery. Most research suggests high fluid pressures in the fault zone and the frictional properties of the fault zone rocks play a major role in SSE occurrence. However, the best way to ultimately test these hypotheses is to actually drill into a fault zone that undergoes slow slip, and take measurements of things like pore pressure, temperature, and stress, and recover samples of the SSE fault zone rocks. Quite a few of the people involved in this IODP effort towards drilling to understand slow slip events are at UCSC, or are UCSC alumni. The connections I developed during my time at UCSC have been absolutely invaluable for getting this project off of the ground.

Last year, I returned to the United States after ten years overseas in New Zealand. I am now a research scientist at the University of Texas Institute for Geophysics, in Austin. Returning to the US has been an interesting adventure, and it has been great to be closer to family. I definitely miss my green hills in New Zealand

(and the cooler weather there), but much of my research is still based in New Zealand so I get many opportunities to go back and visit. One of the things I am most excited about by my move to UTIG is that it has given me the chance to move towards doing offshore measurements of deformation related to slow slip. With the help of UTIG technicians and colleagues at Columbia University, I am in the process of building seafloor pressure sensors to deploy offshore Northern Hikurangi to measure vertical deformation of the seafloor during slow slip events. This is a very exciting development, as up until now, we've been restricted to doing land-based measurements of crustal deformation during SSEs. In March next year, with a group of New Zealand, Japanese, and US collaborators (including Susan Schwartz at UCSC), we will deploy a network of seafloor pressure sensors and ocean bottom seismometers to monitor deformation and seismicity during slow slip.

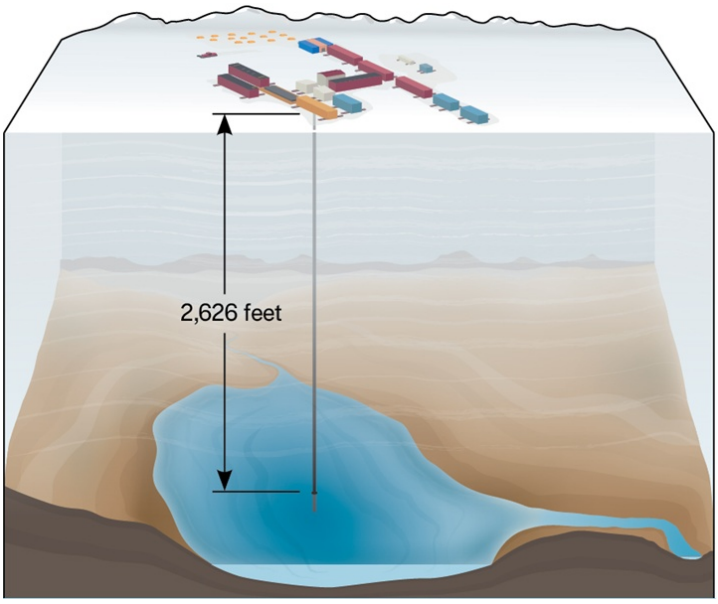


A plan view of the HIkurangi subduction interface fault beneath the North Island, New Zealand showing where the plate interface is locked (red) and building up stress to be relieved in a large subduction thrust earthquake, or steadily creeping (blue). The green contours show cumulative slip on the interface in slow slip events between 2002-2012 (contours in mm). We determined the interseismic locking pattern from campaign and continuous GPS data, while the slow slip events were documented using continuous GPS. Note that the slow slip occurs along the down-dip transition from interseismic locking to steady creep. Black contours show the depth to the interface in km below sealevel.

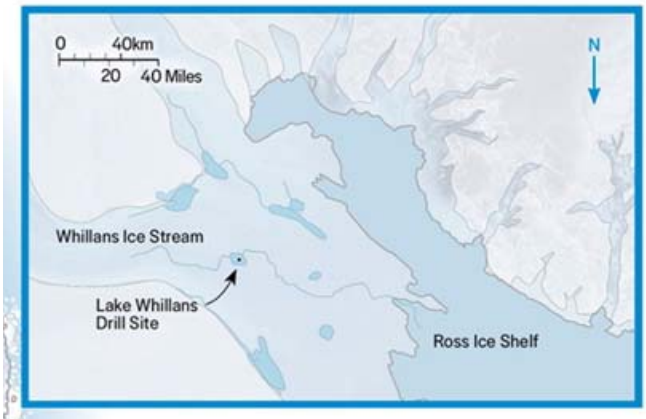
Antarctic glacial lake gives up its secrets, by Prof. Slawek Tulaczyk

One hundred years ago Antarctic explorers discovered Blood Falls, the only place where deep subglacial water, locked beneath ice for millions of years, comes to the surface. The early geological mapping parties did not pay much attention to water, they loaded up their sleds with rock samples and left.
The modern era of Antarctic research started in late 1950s during the International Geophysical Year. It revealed that on the surface Antarctica is our planet's coldest, driest, and windiest place. But even under these extreme conditions, often compared to the surface of Mars, this frozen continent shelters lakes. Over the last two decades hundreds of lakes were discovered beneath the Antarctic ice sheet.
The polar research community found itself itching to access these lakes for direct sampling and measurements. Biologists want to check if microbial life can survive in these remote aquatic environments deprived of sunlight and effectively isolated from inputs of atmospheric gases and organic carbon. Glaciologists have evidence that lakes may impact the rate at which the ice sheet is contributing to sea level changes. Geologists are looking for lacustrine paleoclimate records that could help us determine when different parts of the continent were last deglaciated.

Scientific motivations are compelling, but practicalities of drilling to an Antarctic subglacial lake in desolate places where humans can work only for a few months a year make this itch hard to scratch. Nonetheless, several years ago, I, Andy Fisher, Susan Schwartz and colleagues from a dozen of other US institutions, received funding from NSF to access Subglacial Lake Whillans capped by 800 meters of ice and located half way between the coast and South Pole. Coming up with a catchy acronym for the project, WISSARD (Whillans Ice Stream Subglacial Access Research Drilling), was the easy part. Completing a large multidisciplinary science project supported by a long logistical chain proved to be harder than any of us have imagined. We spent three years navigating the project through various bumps while building a custom made clean drill and other pieces of drilling infrastructure needed to meet our ambitious science plans. We basically had to reconstruct the capabilities of an ocean-going drilling ship, pack that in shipping containers, put the containers on sleds and have huge tractors drive for weeks over snow to get to the drill site. In the meantime, UK funded its own subglacial lake drilling project to Lake Ellsworth and Russian colleagues announced their



Schematic of the WISSARD project.



Location of the Whillans Ice Stream, Antarctica, site of the WISSARD project

plan to connect to Lake Vostok. International media rushed into talking about a ‘new cold war’ and a ‘race.’ Amongst scientists we all just wanted to get our research done.

WISSARD field season proved to be a nail biter. Our drill and drilling platform were completed in late summer 2012, with just enough time to ship them to Antarctica for a test near the McMurdo station. The drilling system passed the test and got packed onto an oversnow traverse, which over two weeks dragged almost 1 million pounds of gear and fuel to Subglacial Lake Whillans. In late December, we heard the sad news about our UK colleagues getting their drill stuck while making progress to Subglacial Lake Ellsworth. In early January 2013 we were ready to fly four dozens of scientists and support personnel, including six Slugs, to the field site, but weather had a different idea. Two weeks of weather delays left the project with just one week to complete all the drilling and science we have been preparing for over 3.5 years. Our work had to stop on February 1st because all personnel must be safely pulled back from all remote camps to research stations due to coming Antarctic winter. While we were at Subglacial Lake Whillans, a tragic airplane accident some 250 miles away provided a stark reminder about the still significant risks of working in Antarctica.

In the face of obstacles, the WISSARD team simply refused to accept the possibility of failure and worked hard around the clock to make sure that Subglacial Lake Whiillans will not get to keep its secrets. Within

UCSC grad student Ken Mankoff preparing the drill.

The drill being deployed.

three days we blasted through 800 meters of ice and completed a two-feet wide borehole to the lake. Over the next four days we collected water and sediment samples and made chemical measurements in the subglacial lake. With time running out, the UCSC team lowered seismic and temperature sensors into the borehole completing science operations. This borehole observatory was designed and built at UCSC by Dan Sampson and Robin Bolsey, with assistance from dedicated graduate (Grace Barcheck, Marci Beitch, Neil Foley, Ken Mankoff) and undergraduate students (Nicholas Geier, Kyle Johnson, Krista Myers, Connor Williams). After our sensors were in place, the borehole was allowed to freeze shut, returning the subglacial lake to its isolated existence.

Within days, the WISSARD biology team officially confirmed that the lake does support surprisingly abundant and diverse microbial life. Tests of the sediment cores containing runny lake mud are still ongoing and may tell us about the history of ice sheet extent in this part of Antarctica. The UCSC team has to wait patiently for a year to get data from our borehole observatory. However, we already have measurements of geothermal flux, the first such direct measurement in Antarctica, and data from surface GPS and seismic stations. Over the next several years, we will use these datasets to understand how Antarctic ice sheet flows over the complex subglacial landscape, which includes lakes like Lake Whillans.

Flying out of our field camp in early February, after a successful but exhausting season, I could not help but

The WISSARD site

think about the amazing leap in science and technology which took place in the century that passed since humans first crossed the icy landscape unfolding beneath our airplane. In early twentieth century people came to Antarctica to manhaul sleds with rock samples collected from surface exposures and to face a high likelihood of never going back. Now we can come and within a month build a small factory in a middle of nowhere to collect data, water, and sediments from beneath the ice sheet. We have great scientific tools to force our data and samples to tell us detailed stories about the history of the ice sheet and its modern state. About half way along the way to McMurdo, our plane passed close to the site where Robert Falcon Scott and his colleagues met their unfortunate end in 1912.

UCSC grad student Grace Barchek.

Dan Sampson testing the seismometer.

Zombie volcano or proto-pluton? Geomorphic insights into mid-crustal magmatic intrusion beneath Volcán Uturuncu, Bolivia

Jonathan Perkins (PhD student)

Uturuncu volcano in its natural habitat

Perched atop the Bolivian Altiplano amidst sparse bunch grass, open sky, and the occasional alpaca, a small, long-dormant dacitic cone volcano named Uturuncu is swelling like a giant balloon. Such is the magnitude of this uplift (~ 1cm/yr at its summit) that Uturuncu has been dubbed one of the fastest growing topographic features in the southern hemisphere. --

Viewed from above, the uplift field resembles a 70 km-diameter bullseye centered on the peak of the much smaller, 15-km wide volcano, signaling a deep unrest. Geodesist Matt Pritchard at Cornell University has tracked Uturuncu's rapid growth since its discovery a decade ago using a remote sensing tool called InSAR (interferometric synthetic aperture radar). Uturuncu's steady rise since the onset of InSAR data collection in the mid 1990s led Pritchard and colleagues to attribute the uplift to an injection of magma (at a whopping ~ 1 m^3/s) from a broad zone of partial melt in the mid crust that underlies much of the region, known as the Altiplano-Puna Magma Body (APMB for short, see Fig. 1).

Naturally enough, the APMB is hypothesized to be the magmatic source for the APVC, or Altiplano-Puna Volcanic Complex, a suite of supervolcanoes responsible for the eruption of over 12,000 cubic kilometers' worth of ignimbrite deposits (essentially immense pyroclastic flow events) over the past 10 million years. This type of prolonged intense volcanism is known as an ignimbrite "flare-up." The evolution of flare-ups are generally categorized by punctuated phases of extreme eruptions followed by longer durations of relative quiescence where magma is being injected and overpressures slowly build within a reservoir. For the past 2 million years or so the APVC has been largely quiet, but it is unclear to researchers whether or not this period signifies the end of the flare-up, or perhaps just represents another lull in the cycle.

Uturuncu, which last erupted approximately 273 thousand years ago, sits directly on top of some of the youngest deposits from this supervolcanic legacy, and its comparatively small-volume dacite lavas indicate eruption from a much shallower source. But this is precisely what makes Uturuncu such an interesting case study, and highlights an important scientific question: why has this long-dormant cone volcano awoken with such vigor, potentially fueled by a magmatic source historically prone to much more violent outbursts?

Of course, there exist a number of scenarios where magma injection into the crust would not signify an eminent eruption, so before scientists ring any alarm bells (or let the media run away with hyperbolic stories about the pending zombie volcano apocalypse) we have to consider what a "benign growth" scenario might imply. If the inferred deep injection of magma beneath Uturuncu remains in the crust and eventually cools and crystallizes, then alternatively what we are observing may be the topographic expression of a pluton being born. This implies that the APMB (its hypothesized magmatic source) may be an extremely large proto-batholith, much like we see today within the Sierra Nevada in our own California backyard.

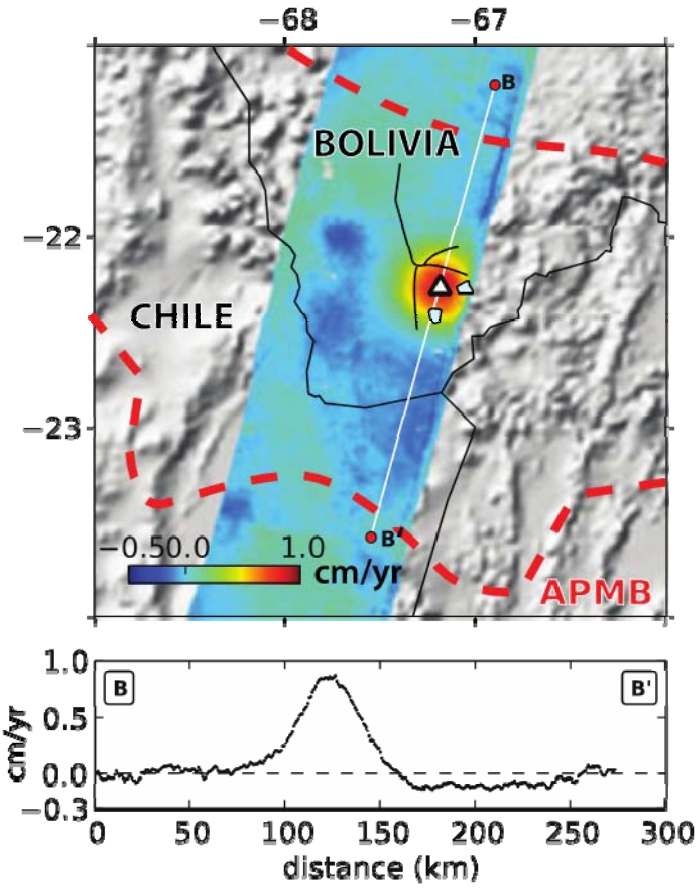
With these end-member scenarios in mind, the PLUTONNNSSSSSS project (no, I didn't just doze off typing this) -- a joint venture between the NSF Continental Dynamics program, the UK's National Environmental Research Council, and a number of South American universities – has set out with a slew of geo-

physical and geological tools to image the crust beneath Uturuncu and better characterize its compositional and deformational history.

So where do banana slugs fit into this multi-dimensional puzzle? As geomorphologists, Dr. Noah Finnegan and I are working toward the latter: understanding the long-term surface deformational history at Uturuncu. Petrologic and numerical modeling work has shown that large silicic magmatic systems take tens to hundreds of thousands of years to grow before erupting, so fifteen years of uplift data from InSAR satellites only represent a mere snapshot in this process. The arid climate of the Altiplano, along with its rich history of Pleistocene lakes, rivers, and glaciers, make it a virtual museum of geomorphic features that may encode information about Uturuncu's longer-term deformational history.

Our goal then is to use these fossilized geomorphic systems to understand just how long Uturuncu been growing, and what that means in terms of its magmatic evolution. We use abandoned shorelines from lakes that flank the volcano as tiltmeters, since they record an originally horizontal datum from which to measure subsequent deformation. Similarly, we can use river valleys that cross the entire uplift field as passive strain markers, as our observations suggest these rivers haven't been geomorphically active since the late Pleistocene. These forensic tools allow us to peer into Uturuncu's deformational past, and, coupled with the forthcoming high-resolution geophysical data from our collaborators, may yield insight on the fundamental relationship between magmatic intrusion, crustal rheology, and surface deformation.

Interestingly, our data from both of these geomorphic systems show unambiguous evidence for pristine, undeformed topography around the volcano. Measured lake shorelines are beautifully flat, and river longitudinal profiles appear to substantively lack any evidence for deformation. Furthermore, we can put a maximum constraint on the onset of Uturuncu's present uplift at less than 1000 years. So what's going on beneath the volcano? Is the uplift we observe from satellites truly a nascent phenomenon? Or perhaps a transient pulse in a longer cycle of uplift and relaxation?



Map of Uturuncu showing uplift anomaly from InSAR measurements. Dashed red line = extent of Altiplano-Puna Magma Body (APMB). Thin black lines near the volcano mark the locations of prominent rivers. Light blue shapes near volcano are locations of prominent lakes. Lower figure shows a cross section (B-B' on upper figure) of surface displacement from InSAR. Figure modified from Henderson and Pritchard (2013, G^3).

Incoming geophysical data may begin to shed light on these questions. Recent acquisitions of InSAR data from multiple look angles have revealed a further complexity to the deformation field around the Uturuncu: a peripheral moat of subsidence surrounding the uplift (see Fialko and Pearse, 2012, *Science*, and accompanying commentary by fellow slug Benjamin Brooks, "Seeing is believing"). Additionally, results from our colleagues' high-resolution regional gravity survey show a zone of anomalously low-density material at depth beneath the volcano (see Del Potro et al., 2013, *GRL*). Paired together, these observations suggest that the unrest at Uturuncu may actually come from a rising magmatic diapir sourced from the Altiplano Puna Magma Body. Though not as hair-raising as the possibility of a growing supervolcano masquerading as a dormant dacite cone, it is a scientific first to be observing in real-time one of the most fundamental processes in the creation of continental crust. Geomorphology has highlighted a large discrepancy in the deformational time scales associated with this process, and though many mysteries remain, may ultimately provide a constraint toward understanding the vital linkages between large-scale magma generation, crustal rheology, and surface response.

Jon Perkins in Chile, 2013

AGU FALL MEETING

San Francisco | 9–13 December 2013

We hope to see you at the Thirsty Bear Brewing Company for our *12th Annual UCSC Earth & Planetary Sciences Alumni Event at Fall AGU!*

When? **Tuesday, December 10th, 2013**
from 6:00pm - 8:30pm

Where? **Thirsty Bear Brewing Company**
661 Howard Street, San Francisco, CA 94105
http://www.thirstybear.com/

Alumni Notes

1973

Matthews, Vince (PhD, 1973): Vince Matthews retired as State Geologist of Colorado and Director of the Colorado Geological Survey on December 31, 2012. Retirement at 10,100 feet above sea level in Leadville, Colorado is fairly busy. Since May, I have a full-time job as Interim Director of the National Mining Hall of Fame and Museum (also on the Board of Directors), am General Chair of the 125th Annual Meeting of GSA this fall, am Co-Principal Investigator for an $11 million CO2 Sequestration study in northwest Colorado that we are wrapping up, am Chair of the Natural Resources Sector of the Business Economic Outlook Forum for Colorado, am a member of the National Steering Committee for America's Geologic Heritage, am Editor for the Colorado Geological Survey's 1:24 geologic mapping program, and am writing an article for Central Colorado magazine. I also do a daily Facebook post on the local geology (http://www.facebook.com/LeadvilleGeology). I am the 2014 recipient of AAPG's Pioneer Award. I was also elected to Honorary Membership in the Association of American State Geologists and received the 2013 Exceptional Service Award from the Colorado Emergency Management Community. Other than that, I am fully retired (I think).

Sullivan, Kathryn (BS, 1973): On August 1, 2013, President Obama nominated Kathryn Sullivan as the new Under Secretary for Oceans and Atmosphere and Administrator of the National Oceanic and Atmospheric Administration, Department of Commerce.

1977

Bond, Marc (BS, 1977): Over 30 years since graduation (Earth Sciences, 1977) I still retain my passion and love for geology. It remains an integral part of my life and career. After leaving UCSC with a B.S. in Earth Sciences and Environmental Sciences and a year with the USGS, I obtained a M.S. in Geophysics from Colorado School of Mines. From there I began a career with the hydrocarbon industry that has exposed me with both fantastic geology and varying cultures. In 1991 my family and I moved to England for what we thought would be a short assignment with BG Group, which has turned into a long-term one where we currently are still living and working in the UK and have even become dual citizens! We also had a brief (4 years) time living in Italy which was a wonderful experience, both professionally and personally.

Recent roles have been challenging and exciting. Perhaps my most geologically interesting post was working the overthrust area of Bolivia using outcrop, seismic and well data to unravel the structural complexity. A great role followed this post where I was the Subsurface Assurance Manger responsible for overseeing all of the technical projects to ensure they were technically robust and accurately portrayed the risk and uncertainty of the opportunity, providing challenge and support. This was a fantastic role in that I was able to see all of the opportunities within BG and provide influence and guidance for the best technical recommendation. More recently, I have changed roles and I am now Head of Geophysics, a role I have aspired to ever since becoming a geophysicist. The journey continues!

Although I have have an amazing career, the roots all come back to my time at UCSC. The wonderful and passionate professors and inquisitive students instilled my passion for geology and discovery of the unknown. After all of these years, I still know that Santa Cruz gave me the foundation for my life and career. I am happily married (over 30 years) with a wonderful wife and two wonderful grown children who have all been an inspiration to me.

1979

Metzler, Chris (BS, 1979): I continue to teach Earth and Space Science at MiraCosta College in north coastal San Diego County. In addition, I serve as Chair of the Department of Physical Science.

Levorson, Mark (BS, 1979): Thanks for reaching out to us old alumni! I still remember the Plate Tectonics course I took from you in 1977(?). It was my first class after returning to school from a two year ski-bum college hiatus. I bombed the mid-term, but eventually recovered. LOL. I received my BS in Geology from UCSC in 1979, following the Paleontology pathway, which integrated well with my BA in Environmental Studies/Natural History degree received at the same time. I received a MS in Geology from the Colorado School of Mines in 1987. I am currently a Principal Hydrogeologist at URS Corporation in Denver, Colorado. I have worked as a consultant for the past 27 years on site characterization and remediation projects involving groundwater contamination (chlorinated solvents, volatile organics, petroleum hydrocarbons, and metals) for commercial/industry clients. Recently, more of my time has been spent on similar issues at abandoned mine land sites for the US Forest Service and National Park Service. My wife Laura and I have two adult children (almost through college) and have been married 25 years. I enjoy road cycling, hiking, skiing, canoeing, and photography. Life is good.

1982

Childs, John (PhD, 1982): John Childs received the 2011 Tobacco Root Geological Society Award for Excellence in Geological Field Work. It is in recognition of his breadth of experience in geologic mapping in the Northern Rocky Mountains, and for his detailed mapping of all types of economic deposits. His high standards and integrity are an example for all geologists.

1991

Orange, Dan (PhD, 1991): It's been quite a couple of years for DanO (and **Phil Teas** [PhD, 1998], too). DanO completed a 2nd Indonesia Mega-Survey for Niko Resources, with 500,000 km^2 of new multibeam data. Following that program, DanO acquired 120,000 km^2 of new multibeam data off Brazil's equatorial margin for Niko. While DanO was surveying these areas, Niko Indonesia geared up for a multi-year exploration drilling program in late 2012, and drilled 7 newfield wildcat wells that included prospects that Black Gold/Niko, identified in the first Indonesia Mega-Survey area. DanO is transitioning to another start-up, ONE (Oro Negro Exploration LLC), that he founded with two other Black Gold founders, including Phil Teas. ONE was created to continue utilizing sea floor mapping as a fast de-risking tool in offshore frontier basins. DanO and Bonnie and their 3 kids are planning to move back to Santa Cruz in summer, 2014 which Dan will use as a base for his ONE activities. In addition to his work in the oil industry, DanO is also collaborating with the US Navy's Naval Oceanographic Office (NAVO) on next-generation multibeam and sub-bottom profilers.

1992

Koehler, Rich (BA, 1992): This year I was elected Vice-Chair of the Alaska Seismic Hazards Safety Commission.

1993

Musielewicz (Barry), Sylvia (BS, 1993): After a few years in the Peace Corps and subsequent travel, I obtained an MS in Water Resources Science from the University of Minnesota. I spent four years working in the Paleoecology lab at Harvard University, and have worked for the last seven years as a research scientist at the University of Washington in Seattle. I work at the Joint Institute for the Study of the Atmosphere and Ocean, and am a federal contractor to NOAA's Pacific Marine Environmental Lab. My primary research is in monitoring ocean acidification in coastal areas and coral reefs using pco2 and other carbon measurements from moored buoys.

1995

Menking, Kirsten (PhD, 1995): Not much has changed on my end since I last contributed, but I'm happy to announce that the second edition of my intro environmental geology textbook will be published this coming winter. The citation is Merritts, D.J., Menking, K.M., and DeWet, A.P., 2014, Environmental Geology: An Earth System Science Approach, W.H. Freeman publishers. I'd be happy if you could include this information in the hopes some of my fellow alums might be interested in previewing a copy for potential adoption!

1999

Meek, Justin (BS, 1999): After graduating from UCSC with a BS in Earth Sciences and BA in Environmental Studies, Justin Meek worked as an environmental planner for over seven years for a private planning and civil engineering firm. In the wake of the "great recession" he returned to school at San José State University (SJSU) to receive a master of urban planning (2010), and later taught a course on community assessment to graduate planning students at SJSU. Justin currently works for the City of Marina and a private consulting firm, M-Group, as a Senior Planner. In addition to his professional work, Justin serves on the local Section Board of the American Planning Association and the Alumni Board of SJSU's Urban and Regional Planning Department. On days Justin is not working, he enjoys living on the Westside of Santa Cruz and is looking forward to becoming a new dad.

2000

Mazzoni, Stefano (BS, 2000; MS, 2002): Stefano Mazzoni is still working as a geologist with Oxy in Bakersfield CA. Projects this year included a stuctural geology interpretation of the complexly-folded Ventura Avenue Anticline and waterflooding shallow-marine / tidal sands at the Buena Vista field in SW Kern County. Travels have included Italy, New Mexico, Colorado, Texas, Colombia and lots of trips to Mammoth. Stefano was a technical vice chair and the field trip chair for a very successful PSAAPG meeting in Monterey in April 2013. The biggest event of the year is yet to come, as he and Heidi anxiously await the arrival of their first-born child in early August!!!

2007

2007

Rowe, Christie (PhD, 2007): All is well at McGill. **Tim Sherry** (UCSC '11) is finishing up his MSc this year and **Ben Melosh** (UCSC '05) is about to submit the first paper from his PhD work. Both are studying paleo-seismic faults in Namibia. **Ben** has been awarded two major scholarships this year, one from an inter-university consortium here in Quebec (GEOTOP) and one from the Earth & Planetary Sciences Dept at McGill. I have also recruited Santa Cruz native **Naomi Barshi** for an MS working on trace element mobility during dislocation creep in feldspars.

2011

Clack, Lauren (BS, 2011): Since graduation I've moved to two different states, currently in Denver, CO, and spent 6 months traveling across Africa. I recently got a job with a telecommunications company working on satellites but am being recruited for an engineering company in Austin, TX to do IT work around the world, traveling to India, London, Australia, Berlin, Singapore, and others about every other month for about 2-3

Sherman, Reid (BS): This August I will have a Masters in Earth Science from the American Museum of Natural History in New York and will be teaching Earth Science at a high school in New York City. More information about the masters program I am graduating from is provided here: http://www.amnh.org/learn-teach/master-of-arts-in-teaching

2012

Shutes, Shaun (BS, 2012): I had the honor to be in both Eli and Francis' class as an undergrad. Since I graduated last year, I have completed UCSC's Master's program for Education. I have recently been offered a job to be a science lab specialist for 1st-6th graders at an Elementary school in Fremont. I am eager to start.

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As we approach the end of the year, please consider making a contribution to the Earth and Planetary Sciences Department at UC Santa Cruz. Our aims are to

- Build the department's endowments
- Provide general support for the department and our students

ENDOWMENTS

The best Earth Studies departments in the nation have major endowments. We are just beginning to build ours. This year, we are focusing on developing two endowments.

GOAL: Raise $50,000 for the Casey Moore Fund

The Casey Moore Fund provides targeted grants for independent research by graduate and undergraduate students.
Current value of the endowment = $99,823
We've made it to the $100,000 mark! Help us reach $150,000.
This would yield enough to provide two awards to graduate students, and several to undergrads, in 2014.

GOAL: Raise $40,000 for the Weber-Holt Fund

The Weber Holt Fund currently provides summer field camp scholarships to meritorious students.
Current value of the endowment = $161,289
Thanks to the generous support of Jerry Weber, Sue Holt, and friends, the value of this endowment continues to grow. With your help, we can break the $200,000 mark.
This would yield enough to provide scholarships for eight summer field camp students in 2014.

Payouts from endowments for 2014 will be calculated based on their value on December 31, 2013. ***Please make your contribution by December 15.***

CURRENT-USE GIFTS

If you would prefer to provide support that can be used immediately, it should come as no surprise that the department welcomes these gifts as well.

GOAL: Raise $25,000 for the Earth and Planetary Sciences Fund

This fund is used to support research and educational activities of graduate and undergraduate students. It also provides much-needed discretionary funds for the department.

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Or visit our department web site at: http://eps.ucsc.edu

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News about myself and other classmates

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
☐ I would prefer my comments to appear only in the Earth and Planetary Sciences newsletter.

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The Earth and Planetary Sciences Department and Institute for Geophysics and Planetary Physics proudly acknowledge their many advocates and supporters. The following people and organizations have made gifts to the department in 2013. Thank you one and all!

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