# Earth Science Newsletter

FALL 2012

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**EARTH SCIENCE**
**University of California, Santa Barbara**
**Webb Hall, Room 1006**
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# Emeritus Profile: Ken Macdonald

*Ken with a trout after a successful day of retirement fishing at Trout Lake, WA 2009*

All introductory geoscience textbooks cover at some length oceanic spreading centers, or the "mid-ocean ridges" that circle the globe, and along with subduction zones and transform faults divide the Earth's surface into several large tectonic plates. Ken Macdonald's research career has established him as the world leader in describing and understanding the processes of crustal formation at these fundamental plate boundaries.

Ken retired in December 2007 after several decades in the UC system including 28 years as a Professor in our department. He is a graduate of UC Berkeley in engineering, and spent 4 years as a research scientist at Scripps Institution of Oceanography (SIO) at UCSD before coming here. "So my UC roots go deep," he comments. He came to marine geology and geophysics through his graduate studies at MIT where he was in the Joint Graduate Program between MIT and WHOI, the Woods Hole Oceanographic Institution on Cape Cod.

At WHOI-MIT he became involved in the FAMOUS Project (French-American Mid-Ocean Undersea Study), which studied the rift valley of the Mid-Atlantic Ridge at 37°N using a variety of then state–of-the-art technologies. His particular dissertation work was to map the structure of the rift valley using the Deep Tow instrument package developed and operated by SIO. This work provided the first look at the actual faults that controlled the rift valley that was found on virtually all "slow spreading" ridges on Earth.

From here he embarked on a career devoted to understanding spreading centers in the world's ocean. "My students, employees and I did our best to understand the tectonics and structure of the global Mid-Ocean Ridge system, the longest mountain range in the world." is how he sums up an illustrious and successful effort lasting decades.

Ken was one of the leaders of the renowned RISE expedition that in 1979 used the submersible ALVIN to discover the hydrothermal "black smoker" vents on the East Pacific Rise (EPR) at 21 °N. This first discovery made the cover of Science magazine and earned the Newcomb Cleveland Prize from the American Association for the Advancement of Science (AAAS) for the expedition team.

Soon after this success Ken moved to UCSB to take his faculty position. The research that followed included numerous graduate students and undergraduates. He says that "I am particularly grateful to the outstanding graduate students I had

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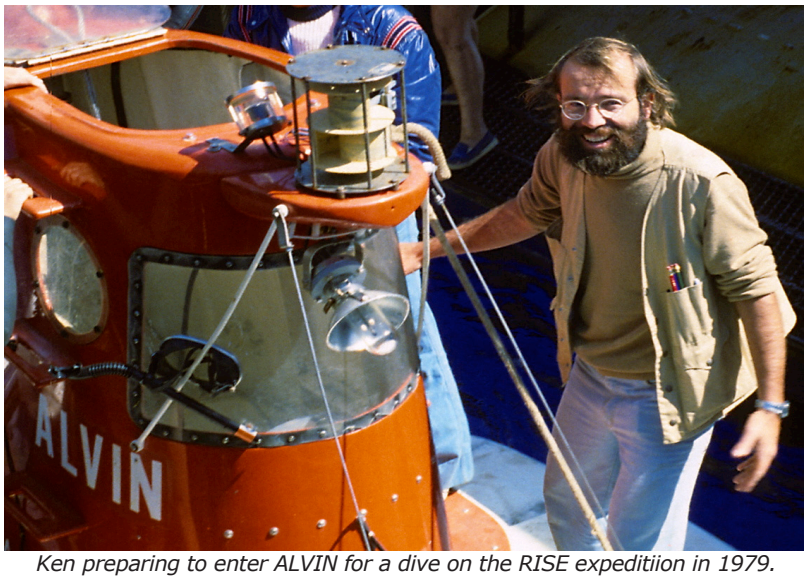
## EMERITUS PROFILE: KEN MACDONALD, *continued from page 1...*



*Ken preparing to enter ALVIN for a dive on the RISE expeditiion in 1979.*

the privilege to work with and mentor and go to sea with…".

Mapping of the EPR crest in several locations discovered the enigmatic overlapping spreading centers. These bizarre plate boundary features turned out to be the tips of propagating rifts, "…which opened the door to recognizing the fine-scale segmentation of mid-ocean ridges, and the connection between segmentation and upwelling of magma from the mantle." as Ken describes it. Working with his graduate students and colleagues Ken has gone further to develop evolutionary models for the ocean ridge system taking into account the three spatial dimensions as well as time.

Ken has received distinctions beyond the Newcomb Cleveland Prize, including the 1994 Cody Prize in Ocean Sciences awarded by SIO. He was the first marine geophysicist to receive this. In 1995 he was elected a Fellow of the Geological Society of America and also of the American Geophysical Union. AGU Fellow selections are restricted to 0.1% of the active membership each year! Following this award, the Institute for Scientific Information recognized him as one of the world's Highly Cited Researchers, pointing out the wide impact of his work. His additional fellowships include elected Fellow of the World Innovation Foundation in 2005, and in 2007 he was elected Fellow of the AAAS.

His teaching at UCSB spanned a variety of both general education and innovative advanced courses including one where he brought students along with him on extended marine expeditions. In the classroom he taught Geol 4 Introduction to Oceanography, Geol 100 Introduction to Geophysics, Geol 135 Geological Mechanics, Geol 138 Heat Flow and the Earth's Interior, Geol 164A Earth System Science- Solid Earth, and Geol 214 Marine Geophysics.

Probably his most popular and innovative course was 181/281 Field Studies in Marine Geophysics, where students had an opportunity to experience first hand ocean–going fieldwork. Ken relates that "I also learned a lot from the many dozens of bright undergraduate students who went to sea with me as part of my course, [181/281] taking students to Easter Island, the Galapagos Islands, Chile, Peru, Mexico, Brazil, South Africa, Tahiti and a number of other exotic locales. Many have mentioned that these expedition-based classes gave them memories and experiences they will never forget, mostly good ones!"

Ken's service to the department included Graduate Advisor and nearly 20 years as Graduate Admissions Chair during which we saw a strong increase in the number of graduate students including those who were on the top of our admission list. He also served the campus on the Program Review Panel, which is entrusted with reviewing and evaluating the performance of UCSB academic departments every few years.

Since retirement Ken has honed his windsurfing skills, spending time refining his jibe on the Columbia near his Trout Lake, Washington summer home he shares with his wife and colleague Rachel Haymon. Along with this summer sojourn they also are spending winter months in Ventana southeast of La Paz, Baja California, windsurfing and fishing. Ken's science activities continue with the Channel Islands National Park during the months Rachel and he are in their Santa Barbara home. He is a volunteer naturalist and is leading whale-watching trips in the Santa Barbara Channel and nature hikes on Santa Cruz Island.

What a brilliant career and what an exciting life! And how fortunate we in the department have been to be able to share these times with Ken.

*"I am particularly grateful to the outstanding graduate students I had the privilege to work with and mentor and go to sea with, including: Jean-Christoph Sempere, Suzanne Carbotte, Laura Perram, Marie-Helene Cormier, Dan Scheirer, John Bicknell, David Castillo, Marian Magee/Castillo, Heather Sloan, Mark Legg, Russell Alexander, Jeff Severinghaus, Keith Sverdrup, Charles Weiland, Scott White, Stacy Supak, Siobhan Corrish."- Ken Macdonald*

## A New Earth Science Award: *The Graduate Student Opportunity Award*

Through their generosity and long-standing comittment to our department, Emeriti Professors Ken Macdonald and Rachel Haymon have spearheaded a drive to fund a new award: the Graduate Student Opportunity Award, which is intended to support the graduate program in Earth Science (including students in the Graduate Program in Marine Science whose home department is Earth Science). The use of this award is intended to be flexible with the primary goal being strengthening the graduate program. For example, funds can be used for graduate student recruitment, financial support, seed money for grants, etc. Rachel and Ken's preference is that funds be used to assist in the recruitment and support of the graduate students of junior faculty, i.e., assistant professors. However, flexibility to respond to needs and opportunities is paramount. All decisions will be made by the Graduate Student Admissions Committee subject to approval by the Department Chair.

The Graduate Student Opportunity Award creates new opportunities for our brightest students to learn from internationally renowned experts in the field, enhance the prestige of the University, and maintain the meaningful and positive connection between the family of Ken Macdonald and Rachel Haymon with the UCSB campus. This new award is now open for contributions from alumni, friends, and faculty (see the enclosed information). In addition to their initial endowment, Rachel and Ken will match the first $4,000 pledged to this fund each year. So, please double your money!

# LETTER FROM THE CHAIR...

As the summer of 2012 draws to a close, I find myself driving across Nevada and Utah with my wife en route to Colorado in order to attend the wedding of one of my doctoral students. We spent many hours today in the Valley of Fire State Park where we were surprised and stunned by the brilliantly colored, water- and wind-sculpted Mesozoic strata that lie below the Roberts Mountain Thrust. These castellated ridges display striking, almost fantastic (in both the current and the original sense of the word) forms. Whereas we both thrill to the magnificent natural palette painted across the landscape, I find myself persistently intrigued by the many mysteries of this overprinted landscape, where I stare at details and ask myself, "How in the world did that happen?" It must be one of the benefits of a geologic career that, after three decades in academia, I still find myself readily surprised and intrigued (and commonly confused) by newly discovered facets of rocks right in front of me and their implications for the geologic evolution of this particular area. I am always thankful that my geologic education enables me both to unravel and appreciate the landscapes through which I travel.

As our faculty shapes its goals for our undergraduate and graduate students, certainly one goal is to inspire the awe and curiosity that drives both successful science and an excitement about the natural world. Another goal is, of course, to provide the intellectual underpinnings that permit our students to make well-reasoned, fact-based, and incisive interpretations of all things geological. We faculty spent many hours this this past year in an effort to revise our undergrad curriculum, especially for our geology majors. In the end, we adopted a somewhat "back to basics" curriculum that includes more petrology and sedimentology, more field work, more lab time, and consequently (and perhaps unfortunately) fewer electives. We'll see how well it works, but the goal is to continue turning out well-prepared, broadly versed, articulate earth scientists.

Meanwhile, our 6-week field camp finished recently. Phil Gans taught the first 4.5 weeks in the Northern Snake Range of eastern Nevada, and John Cottle took the students to Santa Cruz for their final 1.5 weeks. I chuckle to think of the contrasts those students experienced: near 100% exposure and 100° temperatures in Nevada followed by obscure exposure, fog, and sea breezes in the Channel Islands! One student left Nevada after a couple weeks in order to attend a field camp in Minnesota – where she won the award as the top student in their field camp: a testament, she says, to the great training she received here at UCSB!

We also revised our required grad courses this year, such that entering grads will begin their first quarter with five 2-week-long segments taught by teams of faculty. This fall, most of these segments will involve field work, sample collection, and rapid data analysis in order to introduce students to topics and methodologies in several facets of our department's diverse research. In their second term, in addition to preparing a research proposal, new grads will explore scientific ethics, work on back-of-the-envelope calculations, and improve their skills in written, oral, and visual presentations.

This past year has encompassed numerous highlights, several of which are described in more detail in subsequent sections of this newsletter. I will just touch on a few here. David Valentine garnered a lot of national attention for his extensive work on the Deepwater Horizon oil spill. One key result was recognition and description of the role played by bacteria in gobbling up almost all the subsurface methane emitted from the well. Brad Hacker, John Cottle, Andrew Kylander-Clark, and Gareth Seward have spearheaded the development of some world-class laser-ablation mass spectrometry and electron-backscatter facilities that permit unprecedented resolution and synchronous analyses that were previously impossible. These facilities are being used by undergrads and grads both in class and for their research projects. About half of our graduate students are supported by research grants and/or university fellowships, and over 10% have NSF or NASA Graduate Fellowships. An energetic team of grad students competed in the Imperial Barrel competition to evaluate a hydrocarbon prospect. Many individual students participated in outreach such as in ScienceLine (responding online to student questions) or offered short courses to interested high school students.

In talking with our own students, we realized that they could benefit from more access, information, and mentoring with respect to the opportunities and challenges that lie ahead as they finish their studies. In response, we held an inaugural Careers Panel with both semi-formal and unscripted discussions with departmental alums who shared their pathways and perspectives on careers in earth science. The panel was followed by our annual Graduate Research Review in which each grad presents and defends a poster describing their research. Our students expressed a unanimous desire to have similar career panels in subsequent years. Hence, our intent for the future is to repeat these two events and to hold them

*continued on page 4...*

## LETTER FROM THE CHAIR, *continued from page 3...*

on the Friday at the beginning of the "All-Gaucho Reunion" so that alums and friends of the department (as Uncle Sam used to say, "This means YOU!") who would enjoy the research review and/or would like to chat informally with students about career pathways might be able to attend and combine several events.

We had no retirements this year, nor any new faculty appointments. Each of our recently appointed assistant professors (John Cottle, Syee Weldeab, and Alex Simms) have been busy setting up multi-faceted research programs. We were delighted that Lorraine Lisiecki was awarded tenure this past spring for her contributions to teaching and paleoclimatic research. Recently, we received permission to recruit a new assistant professor. We are casting a broad net (geochronology-geochemistry-petrology-mineral physics) in hopes of strengthening both our field-based and analytical programs.

As you may know, state support for the UC system was cut again this past year (~$250M), and unless the governor's proposals for increased taxes to support schools passes this fall, much larger cuts are likely. Fortunately for us, our departmental alumni, faculty, and friends were very generous and donated over $100,000 to the department this past year. Our deeply felt appreciation for this support cannot be adequately described in a few words, but perhaps a few examples can illustrate the role these donations play. Every participant in summer field received at least $2k to help defray their costs. About half of the transportation costs for every field trip in each upper division and graduate course were subsidized with these funds. Numerous students were able to attend their first academic conference or meetingusing support from our alums and friends. The halls of Webb Hall are being brightened with new HDTV screens, posters, and a wall-sized cross section depicting the geology spanning the Channel Islands to the Santa Ynez Fault! As you are probably aware, some of our funds are dedicated to specific purposes, e.g., support for volcanology or field studies. Following their recent retirements, Professors Rachel Haymon and Ken MacDonald have very generously established a new charitable fund in our department termed the Graduate Opportunity Fund with the goal of providing support during the academic year to an outstanding graduate student. This new fund is now open for (and very much welcomes) your support!

As I prepare for my second year as departmental chair, I am consistently impressed with: the innovation and energy displayed by our faculty; the dedication and skill of our staff; the persistence, quality, and creativity of our graduate students; the energy and "ready-for-anything" attitude of our undergraduates; and the concern and generosity of our alumni and friends. I hope that together we can make the coming year even better than the last! Thanks for your help! Rock on!

# WHAT ARE THE ALUMNI DOING?

Amanda Willingham, c/o S12 MS, has been working as an exploration geologist for a gold exploration company called Gold Canyon Partners in central Alaska.

Kathryn Fry, c/o M12 BS, will start the Master's program at the University of Texas- Austin the the Fall.

Suvi Flagan, c/o F11 MS, is an instructor at Ventura College.

Joseph Dargel, c/o F11 BS, is in graduate school in hydrogeology at Cal State University Long Beach.

Jiana Ten Brinke, c/o W11 MS, works as a Project Coordinator for Resource Conservation Partners in Ventura.

Adam Ginsburg, c/o F11 MS, works for a local Santa Barbara company, Campbell Geo Inc. as a Geologist.

Colin Amos, c/o M07 PhD, completed a Mendenhall Postdoc at UCB and is an Assistant Professor at Western Washington University.

Susana Custodio is an Assistant Researcher in the Institute of Geophysics at the University of Coimbra, Portugal

Jesse Mosolf, c/o M12 PhD, is working for the Montana Bureau of Mines and Geology at Montana Tech in Butte as an Assistant Research Professor.

Molly Zimmerman, c/o S11 BS, is heading to Colorado State University, Fort Collins this coming Fall. where she'll begin the Peace Corp Master's Internat'l Program.

Joseph Goode, c/o S11 PhD, works for HESS Oil Company in Texas as a Geologist.

Lauren Mosley, c/o S12 BS, will continue doing research with Prof. Susannah Porter at UCSB.

Emily Peterman, c/o W09 PhD, is an Assistant Professor at Bowdoin College.

Eryn Burkhart, c/o S12 BS, is in the 5-yr BS/MS program here at UCSB and is studying seismic nucleation of large earthquakes.

Allison Duvall, c/o M03 MS, completed a postdoc at U of Colorado and is now a Coordinator for the newly created Applied Geomorphology program at the University of Washington.

Christy Till is a Mendenhall Postdoc with the USGS in Menlo Park

Jeanette Hagen married Martin Wipf in May in Houston. where she works for ExxonMobil

Eva Von Thury, c/o M12 MS, will be continuing her employment with Fugro Consultants.

James Proffitt, c/o S12 BS, is pursuing doctoral research in vertebrate paleontology and evolution at the University of Texas- Austin .

Katherine Zeiger, c/o M11 BS, works as a Geological Intern with Stantec Consulting in Irvine, CA.

Celso Alvizuri, c/o F11 MS, continued on to a PhD program at the University of Alaska.

Jennifer Van Pelt, c/o W11 MS, is now an Engineering Geologist with MWH Global.

Elizabeth Lovelock, c/o F10 MS, is a PhD student at the University of Idaho.

***ATTENTION: ALUMNI***
***If you have news to share about yourself or fellow UCSB geology alums, please feel free to email that info to:***

***gs-graduate-assistant @geol.ucsb.edu***

# 2011/2012 Earth Science Fund Drive

We had an outstanding response to our funding appeals this year. **Thank you all!!** It is extremely gratifying to see our alumni taking a lasting and consistent interest in their department. When potential donors recognize that we receive substantial support from our alumni, it enhances the value of our "product" in their eyes, and we are taken more seriously. The department has benefited significantly from employer matching gift programs. Be certain to check with your company when you make your gifts this year!

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Mr. Brian I. Wolf, '86
Jane Woodward, '80
Mr. Grant Yiu-hing Yip, '03
David J. Young, PhD '05
Mr. Joseph A. Zamudio, '77

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# Distinguished Alumni

Every year, the department honors one or several of its alumni, celebrates their accomplishments while providing our current students with exemplary role models.


*2012 Distinguished Alumni Award Recipients: (L-R) Bradley Singer, Bruce Laws & Scott Hornafius*

## Scott Hornafius

Scott Hornafius received our Distinguished Alumni award this year. Scott came to UCSB from Colgate University where he majored in geology and was introduced to the new theory of plate tectonics, which captured his imagination. At UCSB he originally intended to study ophiolites, including the Samail in Oman, with Cliff Hopson. But he became aware of the southern California tectonic rotations project then underway with Bruce Luyendyk and his students. At the same time, Don Weaver was leading a project to study the Monterey Formation for Mobil Oil. Scott thought that these two could be combined with a project aimed at paleomagnetism of the Monterey. His reasoning was that although the volcanic rocks being studied by Bruce's students were the low-hanging fruit, stratigraphic information on the timing and rate of rotations was crucial. At first this approach wasn't working out, with many Monterey samples showing remagnetization. Then he discovered that the dolomite beds in the formation had preserved the original depositional magnetization; the cementation process had in effect sealed it in. From that point, he completed an exhaustive study that defined the timing and rate of this Neogene event.

After obtaining his Ph.D. in 1984 his first job was with Mobil Oil in locations that included Papua New Guinea and the U.K. One assignment was back in Santa Barbara, where he was part of the Clearview project that proposed to remove Platform Holly offshore from UCSB and drill from onshore near Ellwood using horizontal wells. During that period, he and Bruce reconnected to start the marine hydrocarbon seeps study that is still underway in our department. When Exxon bought out Mobil in 1999, Scott chose to start his own oil company. He convinced venture capitalists to join together to form MegaEnergy to explore for natural gas in undrilled anticlines in his home state of Pennsylvania. After years of up and down drilling success, MegaEnergy began focusing on the Marcellus Formation and was one of the first companies to test the shale gas potential using hydraulic fracturing. In 2010 Scott sold most of the assets of MegaEnergy and "retired".

He now has two major activities; one is as executive director of a new shale gas company in western Australia, and second as a visiting researcher at the Earth Research Institute at UCSB, where he is interested in studying the contribution of natural seeps to the global methane budget. Scott lives in the Denver area with his wife Lisa and daughter Hayley; his older daughter Kayla lives in Chicago. When not pursuing his professional interests, Scott can be found on the expert ski slopes around Breckenridge, Colorado.

# Distinguished Alumni

## Bruce Laws

After arriving at UCSB in 1974, Bruce Laws was lured him into geology by our field-based courses. Following graduation in 1978, Bruce stayed on to work under Professor Bruce Luyendyk's guidance. Two years later, he completed a MSc in geophysics that was focused on magnetic properties of sheeted dike complexes in the Oman ophiolite. Remember that this was a time one discovery for plate tectonics, and the emplacement of ophiolites was still an intriguing mystery. Given his love of adventure and a desire to see the world, Bruce moved directly from UCSB to Chevron Overseas, where he worked for the next 19 years. Although nominally based in San Francisco and San Ramon, Bruce spent 3-to-5 years each in several extended overseas assignments. In his first several years, he worked his way up from geophysical data processing to become a developmental geologist, before becoming the supervisor of geological operations in the jungles and offshore areas of Papua New Guinea. By the time he went to Lagos, Nigeria, 5 years later, he was a division manager of geology from Chevron. Bruce then spent three years as the manager of exploration and development for Chevron's operations in Angola, before moving to Luanda, Angola for his final four years with Chevron. In 2001, Bruce left Chevron for Houston-based Murphy Oil, where he was a vice president for new ventures and later the regional vice president for Europe, Latin America, and Africa. Seven years later, Bruce jumped to his current role as the president of Maersk Oil in Houston. You may have heard of Maersk: it's mostly known as a large shipping company, but it has a good size oil and gas operation. Rather unusually, Maersk is one of a very few large, yet family-run multinational firms. Given Bruce's appealing combination of competence, experience, and modesty, it seems somehow appropriate that he is working for a family-run company! Under his guidance, Maersk Oil in Houston grew in the past four years from ~25 employees to over 200! Simultaneously Bruce has guided development of a selective and integrated three-year training program that blends extensive overseas assignments with focused training in exploration, production, and management. Bruce and his wife Cynthia have 6 children – a blended family like the Brady Bunch. Bruce has a passion for skiing, getting his car on the track, and continuing to see the world.

## Bradley Singer

After graduating from Santa Paula High School in Ventura, County in 1978, Brad Singer began at UCSB as a Nuclear Engineering major. He took a geomorphology course taught by Richard Norris and was swayed toward a professional career in Geology by field trips to the Mojave Desert, Point Sal Ophiolite, and San Gabriel Anorthosite – the latter trips led by Cliff Hopson. Volcanology won over as a life-long passion as a result of Cliff's memorable lecture on the 1980 Mt. St. Helens eruption in his petrology class and after seeing the crater and lava dome first-hand with Harry Glicken in 1982 following the Poleta Folds field camp taught by Rick Sibson. After earning a BA from UCSB in 1983, Brad pursued an MS degree at the University of New Mexico on the origin of Rio Grande rift andesites, and in 1990 completed a PhD in Geology at the University of Wyoming, where he focused on the origin of Aleutian Island Arc magmas (a subject he first learned about in Tanya Atwater's tectonics course!). Brad learned K-Ar dating by measuring several of his Aleutian PhD samples at the USGS Menlo Park laboratory under the guidance of Marvin Lanphere. While at the University of Wyoming, Brad met Teri Boundy, a UCSB Earth Science alumna (BA 1986) who was pursuing an MS degree in Geology. Brad and Teri have been married since 1993, and their daughter Zoe will attend the University of Chicago beginning in the Fall of 2012.

Brad's academic career began in 1990 with a visiting professorship at the University of Michigan and was followed by a post-doc with Mike Dungan at Southern Methodist University, where he initiated field-based research on arc volcanism in Chile that has continued for 20 years. During the course of this initial project, he and Laurie Brown discovered – near the bottom of the glacially-exposed lava flow sequence – a remarkable recording of the last reversal of earth's geomagnetic field. This serendipitous finding occurred when research on the geodynamo was undergoing a renaissance and there was a voracious appetite for new, detailed volcanic and sedimentary records of polarity reversals and excursions. Thus, Brad developed an 40Ar/39Ar geochronology research program, first at the University of Geneva, Switzerland (1993-1999), and since 1999 at the University of Wisconsin-Madison. Singer's research is diverse and includes: (1) the volcanic and magmatic evolution of subduction zones (the Aleutian arc, the Andean Southern and Central volcanic zones, Central American Volcanic Arc), (2) the Quaternary history of earth's geomagnetic field (data from volcanic field sites in Chile, Argentina, France, Italy, Iceland, New Zealand, Australia, Hawaii, Canary Islands, Tahiti, Cape Verde, Ethiopia, and China), (3) the Pleistocene-recent history of glaciation in the Patagonian Andes, and (4) the chronostratigraphy and evolution of Eocene and Cretaceous basins of the Rocky Mountains. Brad has supervised 6 PhD and 15 MS students since 1998. The UCSB undergraduate curriculum of the day emphasized breadth across earth science subdisciplines as well as the importance of careful field craft. Brad claims that he traces his success to the excellent preparation while at UCSB, both in the classrooms and in the outdoors. Singer is currently a full professor and Chair of the Department of Geoscience at the University of Wisconsin-Madison.

# STAFF NEWS

## Alice MaCall: new Undergraduate Program Assistant

Alice began her job as the interface with undergraduates and their favoriate problem solver in February, 2012. She's a welcome addition to the front office.

Alice eating cuy (guniea pig) with relish in Cuzco, Peru

In her best-selling autobiography, Alice writes:

I graduated in 2009 with a BA in Geography from UCSB. I was born in California. My parents were political asylees from El Salvador, and soon after I was born, we moved to Montreal, Quebec, Canada, but please do not ask me to speak French because it's atrocious! I've also lived in Los Angeles, El Salvador, the Ozarks in Arkansas, and Santiago, Chile. I love to travel, read, and write. One of my favorite poets is Pablo Neruda. I really enjoy working with all the Earth Science students they are a friendly and an intellectually challenging bunch! The academic advising is definitely my favorite aspect of my position. I would say that the most challenging is working on that quarterly schedule! I love mountain biking, I have a pretty prominent scar on my neck as proof!

# FACULTY NEWS

## Congratulations to Professor Lorraine Lisiecki for achieving Tenure!


Photo credit: Santa Barbara Newspress

Lorraine Lisiecki is originally from South Carolina; she earned bachelors and masters degrees in Earth, Atmospheric and Planetary Sciences from MIT and a PhD in Geological Sciences from Brown University. For her thesis with Prof. Tim Herbert entitled "Paleoclimate time series: New alignment and compositing techniques, a 5.3-Myr benthic δ18O stack, and analysis of Pliocene-Pleistocene climate transitions," she was awarded the 2005 Joukowsky Outstanding Dissertation Award from Brown University and the 2008 Subaru Outstanding Woman in Science Award from the Geological Society of America. She received a NOAA Climate and Global Change Postdoctoral Fellowship to work Maureen Raymo at Boston University from 2005-2007 and joined the UCSB faculty in 2008.

Lorraine studies Plio-Pleistocene glacia tions using computational approaches to the comparison and interpretation of paleoclimaterecords. Since arriving at UCSB her research has focused on the cause and effects of ocean circulation change in the Late Pleistocene. In 2008 she was lead author on a Nature paper that disproved the long-standing hypothesis that North Atlantic Deep Water formation was controlled by "Milankovitch forcing," i.e., northern hemisphere summer insolation. This paper was followed by several others on deep water circulation change, including a 2010 paper in Geophysical Research Letters, which reconstructs atmospheric CO2 levels over the past 1.5 Myr. She also recently received a 4-year NSF grant, in collaboration with UC Davis and Woods Hole Oceanographic Institution, to develop a 4-dimensional reconstruction of ocean circulation changes with a virtual reality simulation using KeckCAVES at UC Davis. Lorraine currently has two graduate students, Joe Stern and Carlye Peterson, who are studying ocean circulation and carbon cycle changes over the past glacial cycle. She also developed a new graduate class, 201C Mathematical Methods in Earth Science, in which she teaches statistics, modeling, and Matlab programming.

Lorraine has had several extraordinary personal experiences since joining the faculty. In November 2008 the house she and her husband, Phil, were renting burned down in the Tea Fire, the day before she left to go on a research cruise in the Santa Barbara basin. Luckily, they had time to evacuate most of their belongings. Then, in February 2011 Lorraine and Phil became the parents of triplets: Robert, Erik, and Devin. The whole family is doing well and enjoying life in Santa Barbara.

# FACULTY NEWS

## *From the Oil Seeps of Santa Barbara to the Deepwater Horizon*

by David L. Valentine, Professor of Earth Science, UCSB

As a graduate student in Earth System Science at UC Irvine, I participated on a short research expedition to the oil and gas seeps off Santa Barbara: an expedition that changed my life. I was awed then by sheets of oil and gas flowing from the seafloor and intrigued by the chemical and microbiological secrets the seeps held. These sites never made it into my dissertation research, but three years later their proximity served as an unneeded bonus to entice me to UCSB. Since arriving in 2001, I have been using the Santa Barbara region as a natural laboratory to explore the tightly coupled geochemistry and microbiology of oil and gas released to the environment. Jointly with a long list of collaborators, students, and postdoctoral researchers, I have sought to understand the chemistry that underlies oil and natural gas, the processes that affect the fates for these hydrocarbons in nature, and the microbial ecosystems that have evolved to produce and consume hydrocarbons. Those who know my lab group will note that my intellectual interests have drawn an eclectic scientific mix including chemists, biologists, Earth scientists, oceanographers, and engineers, with oil and gas seeps being one of our focus areas.

As with most scientists, I struggle to relate my scientific interests to non-scientists and have long labored to translate basic aspects of my work on oil and gas into stories that elicit curiosity amongst non-scientists and enhance public appreciation of basic science. I am driven by the principle that basic research should be supported by society for the benefit of all, but that scientists need to explain their work better to that society and highlight examples where basic science made a difference. Science is about discovery and creation of new knowledge, and I often tell people that *sometimes you need to make a discovery before you know if it's going to be important.* For over a decade my research sustained some societal relevance, and at the least I was able to advise people on how best to remove tar balls from their feet ☺. But the April 2010 explosion of the Deepwater Horizon drilling unit and months of petroleum discharge to the deep ocean provided a level of relevance that I never anticipated. This disaster also provided an opportunity I could not pass up, an accidental experiment in a far-away sea, that I was compelled to study. Here I'll focus on the scientific aspects of this disaster; perhaps in a future Newsletter, I'll discuss my involvement in other aspects relevant to the media, legal, and policy arenas.

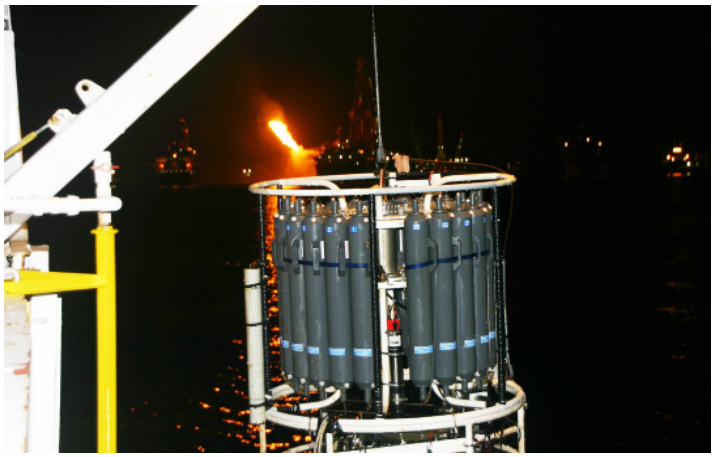
Within a week of the Deepwater Horizon sinking, it was apparent that oil was flowing into the ocean from deep beneath the sea floor at an astonishing, but undefined rate. Later it was determined that the flow was enough to fill the gas tank of an SUV about two times every second, but all we had to go by initially were snippets of video showing a gush of oil coming into the ocean. Oil was the clear focus of public attention, but I was also interested in other components of the discharge: natural gases. When oil is generated in deeply buried sediment, natural gases such as methane, ethane, propane, and butane are generated too, typically outnumbering oil on a molecule-to-molecule basis. When oil is drawn from the ground the natural gas comes with it, with different proportions characteristic of different reservoirs. Natural gas behaves differently from oil, and I surmised early in the spill that these differences would ultimately characterize the uniqueness of this mile-deep disaster. From the outset, two properties of the natural gas seemed most important to the event: their tendency to form ice-like solids in the deep ocean, and their ability to dissolve completely into ocean water. When natural gases are exposed to the cold temperatures and high pressures of the deep ocean, they form solid ice structures known as a gas-hydrates or clathrates. I have dived to the deep sea many times in the submarine Alvin, where I have sampled naturally occurring gas hydrate; in my experience, they have a nasty tendency to gunk up any surface they contact with an icy slush. When BP announced their intent to deploy a containment cap over the ruptured well, I was asked by an *LA Times* reporter if it would work. I predicted in print that it would fail because of clogging by gas hydrate. Unfortunately my prediction was correct, and months went by before the well was finally sealed. Whereas gas hydrates caused technical problems in the emergency response efforts, the solubility of natural gas raised interesting scientific questions for me, as I expected all the gas bubbles would dissolve during the mile-long trip from sea floor to sea surface. This expectation led me to propose a method by which the total influx of oil could be estimated by tracking the plumes of natural gas trapped in the deep ocean. This methodology and initial results were published in *Nature* in May 2010, while oil was still flowing freely into the ocean. Ultimately my collaborators and I were able to use a derivative of this approach to estimate the total release, yielding values consistent with the official government estimates. Even in the early days of the event, it was clear that a major oceanographic presence was needed to track the fate and impacts of the discharge. A postdoctoral researcher in my group, Molly Redmond, began sampling in May 2010, as I worked to obtain rapid response funding from the Dept. of Energy and National Science Foundation (NSF), and to secure use of a scientific research vessel jointly with a

*continued on page 10...*

## Deepwater Horizon, *continued from page 9...*

long-time collaborator, John Kessler. Several other members of my lab group, Stephanie Mendes, Chris Farwell and Monica Heintz set aside their own work and scrambled to prepare the lab for at-sea experimentation. We were on scene at the spill site by June, 2010, aboard the research vessel *Cape Hatteras*, where we were able to identify a series of subsurface plumes containing natural gas at concentrations up to 100,000 times natural background levels. The plumes were at water depths between 3000-4000 feet, and the plume's oxygen was in decline. We worked to within a few hundred feet of the downed wreckage of the Deepwater Horizon while two massive oil rigs and hundreds of vessels worked develop a hypothesis as to what was occurring, with the path forward being to test this hypothesis in several ways with instrumentation waiting in the home laboratory. At the termination of the cruise, all the participants went into rapid analysis mode, and within a month we had the chemical, microbiological and oceanographic data we needed to understand what was happening in those contaminated waters around the flowing well. Surprisingly, propane was the star, being consumed very rapidly by a distinctive bloom of bacte ria and accounting for most of the declining oxygen. These results provided a host of insights

*On scene with dispersant teams*



*Sampling array ready for nighttime lowering a mile deep*

into the deep plumes and allowed us to predict the extent and rate of oxygen decline that was of great ecological concern. By September, we published these results and predictions in *Science*. (More than 10 subsequent papers have been published subsequently. For a full listing, please visit my website: http://tinyurl.com/8kxl8wx).

Although propane was important in the subsurface plumes during our cruise in June, 2010, I knew that it had been eaten quickly by bacteria, whereas methane was the single most abundant compound discharged, and was not being eaten quickly at that time. I got an opportunity to track the methane plumes when John Kessler and I were asked to lead a series of response-phase cruises in September and October of 2010, using the NOAA ship Pisces. With little more than 10 days notice, the hard-working graduate students, postdoctoral researchers and undergraduates from my group again mobilized our laboratory for at-sea research. The Pisces was well equipped and the fastest of almost two-dozen response vessels on the water; as a result we were able to track the Deepwater Horizon's submerged plume with over 100 locations from Florida to Texas. The deep plume contained residual oil and chemical dispersants that had been added at the ruptured well, it was missing some of its oxygen, and it contained a distinctive population of bacteria. But methane was missing – where did it go? Sitting in the galley of the Pisces, we surmised from the evidence that nearly all the methane had been consumed by bacteria. We designed and then performed additional tests at sea, and later in the home laboratory, to test this hypothesis. All evidence pointed to the conclusion that methane had been consumed by bacteria. Our results caused some controversy among the community of scientists that study ocean methane (including a formal exchange in the Science), but our findings remain on firm ground with subsequent evidence further supporting our interpretations.

One of the lingering questions that remained after the well was capped was whether the application of chemical dispersants prevented environmental damage. In fact, this question remains contentious to this day. Dispersants were applied in two ways during the Deepwater Horizon incident: at the surface by aerial spraying, and directly into the gush of oil, 1-mile deep in the ocean. Dispersants are meant to break the oil into bite size pieces that are more available to bacteria and to prevent the formation of overwhelming surface slicks. During our expeditions, we collected samples for dispersant analysis, which was conducted by Liz Kujawinski at Woods Hole Oceanographic Institution. Liz had developed a new analytical procedure for trace-level analysis of a key dispersant ingredient, and we conducted the sampling in such a way to identify where the dispersant went. What we found was surprising: dispersant applied at the sea floor had partitioned into the deep plume, but unlike the natural gas, it was not readily biodegraded. We found low levels of dispersant trapped in the deep plumes over 100 miles from the incident and two months after applications had ceased.

A second issue that lingers in the aftermath of Deepwater Horizon is where all the oil and natural gas went after its discharge from the ruptured well. To tackle this issue in a meaningful and comprehensive way, I joined forces with a group of geochemists from across the country. We held a two-day workshop in Boulder and developed several independent approaches to quantify the flow along different pathways that oil and gas followed in the environment following their

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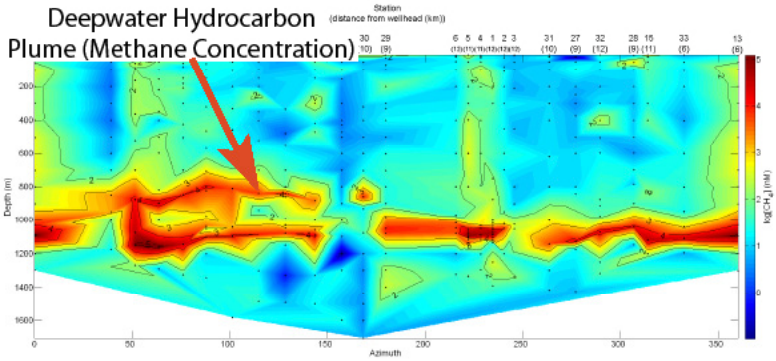
discharge, including an assessment of error. We waded through issues including oil droplet size distributions and rise velocity, solubility of aromatic compounds, precipitation of waxes, rates of bacterial metabolism, and atmospheric monitoring by jet airplane. The result was a synthesis that estimated the partitioning of oil along different transport pathways in the ocean and atmosphere, and that happened to independently corroborate the official government estimates for total discharge.

The Deepwater Horizon provided the unique opportunity to find out how microbes would response to an irruption of oil and gas into the deep ocean. Microbes are the smallest of Earth's creatures, and I have long been intrigued by the way their collective action impacts the chemistry of our environment. Microbes are also voracious eaters (on a pound-to-pound basis), and evolution has honed numerous lineages to consume hydrocarbons and natural gases. Whereas many microbial lineages are known to grow from eating hydrocarbons, we know little about many of these lineages, even less about which organisms might be active in the deep ocean, and very little about which organisms each which hydrocarbon type. Capitalizing on the opportunity provided by this event, Molly Redmond and I sampled microbes throughout our expeditions and conducted experiments shipboard and in the home laboratory to pick apart the ecology of microbes that bloomed in response to the oil and gas irruption. In one such experiment, we collected bacteria-laden water samples from the deep plume and fed them special hydrocarbons containing a heavy isotope of carbon. Some bacteria grew, and we were able to physically separate the genetic material of these 'heavy bacteria' from the genetic material of the many other microbes present. By then sequencing parts of the genome from just the 'heavy bacteria', we we were able to identify several of the lineages responsible for consuming specific hydrocarbons.

Working through the mass of data from the Deepwater Horizon, I began to recognize several patterns that related the community of microbes to the extent to which different hydrocarbons had been consumed. To explore these relationships, I developed a quantitative model that linked the discharge of individual hydrocarbons to the growth of bacteria that ate that particular compound. I soon recognized that this approach needed to consider the deep ocean currents that moved deep waters about the Gulf. Fortunately, UCSB has an expert on this sort of issue, and I invited Igor Mezic, a professor of Mechanical Engineering, and several of his collaborators to integrate the movement of water masses with the chemical and microbiological relationships I had identified. We created a comprehensive model that explained many mysterious observations made during the response efforts. It turned out that the deep ocean waters swirled like a giant washing machine around the Gulf. They would come over the wellhead and become exposed to hydrocarbons. The waters would flow away from the well head, forming a deep plume, and the bacteria would begin to bloom – feasting on a subset of the hydrocarbons. But what surprised us is that the plumes came back again and again, sometime a month or more after their first exposure. These mature plumes had already experienced a bacterial bloom and were primed with a population of bacteria ready and able to consume hydrocarbons, rapidly. This washing machine effect significantly impacted hydrocarbon consumption in the deep plumes and provided a holistic perspective that reconciled otherwise contradictory findings.

A final study I will highlight here considers the tar balls that continue to wash up on the shores of the Gulf of Mexico. Beachgoers around UCSB have long dealt with the tar balls that wash ashore from natural seepage, and I've long wondered what that tar actually is. Years ago I came to this startling conclusion: nobody knows! (Less startling perhaps is that very few people seem to care.) Several months before the Deepwater Horizon sank, I received a collaborative NSF grant with Chris Reddy of Woods Hole to address the issue of what tar is and how microbes might impact its formation. Originally our intent was to focus this work on natural seeps, but the Deepwater Horizon event provided a comparison case with a well-known starting material. Using a host of samples ranging from the gushing wellhead to surface oil slicks to beached tar balls, we were able to track what happened to the tar from Deepwater Horizon. What we found was interesting and surprising, and counters the dogma in oil spill research that hydrocarbons are readily weathered to their mineral components. We found that the mass of tar increased over time as hydrocarbons were chemically converted to tar by the addition of oxygen atoms. That is, an as-yet undefined fraction of the hydrocarbons that were thought to have been broken down were instead converted to another form that lingers for much longer in the environment.

Reflecting back on the discoveries we made as a result of what I refer to as a 'forbidden experiment', I remain surprised that my curiosity about the chemistry and microbiology of hydrocarbon seeps put me in a unique position to help understand many immediate effects of the largest maritime oil spill in US history. But what does not surprise me is that the scientific approach led us to a greater understanding of what was happening in the cold, dark ocean depths as oil rushed in, or that basic science proved its worth yet again by addressing many of societies' concerns about the Deepwater Horizon incident.




*The deep-ocean methane plume that fed the bacterial bloom!*

# IN MEMORIAM

## *Robert M. Norris, Professor Emeritus, 1921-2012*

Professor Bob Norris and his close friend, colleague and mentor Bob Webb, were the founders and foundation of the Department in the 1950s. Unless you knew of what they did in those early days, you might not realize the contributions and significance of their formative efforts in transforming a so-so applied arts school into a distinguished campus of the University of California.

During his long UCSB career, Bob taught the introductory physical geology course, geomorphology, geology of California, and the spring field mapping class in Tick Canyon. The Robert M. Norris Prize in Field Geology honors his teaching efforts in that course. He also organized and taught the first University of California course in Marine Geology outside of Scripps. This course led his student, Bob Ballard, discoverer of the "Titanic", to a career in marine exploration.

In 1981, Bob received the Neil Miner Award from the National Association of Geology Teachers for "exceptional stimulation of interest in the geologic sciences", the highest award conferred by that organization. Also in 1981, he was the recipient of the Robert Wallace Webb Award that is presented only occasionally by the Far Western Section of the American Geological Institute for sustained excellence of Earth Sciences teaching and sustained exceptional service to the Earth Science teaching profession.

Bob was the Department's first Chair from 1960 to 1964. From 1970 to 1975, he was Director of the Santa Cruz Island Field Station when that entire island, except its eastern end, became part of the University of California's National Reserve System. His research centered on geomorphology, especially sand dunes and shoreline erosion problems. While on sabbatical at the New Zealand Oceanographic Institute, he led three cruises that investigated Holocene shelf sedimentation. Bob was also a member of the International Geophysical Year "Downwind Expedition" off the west coast of South America (1957-58), including Easter Island.

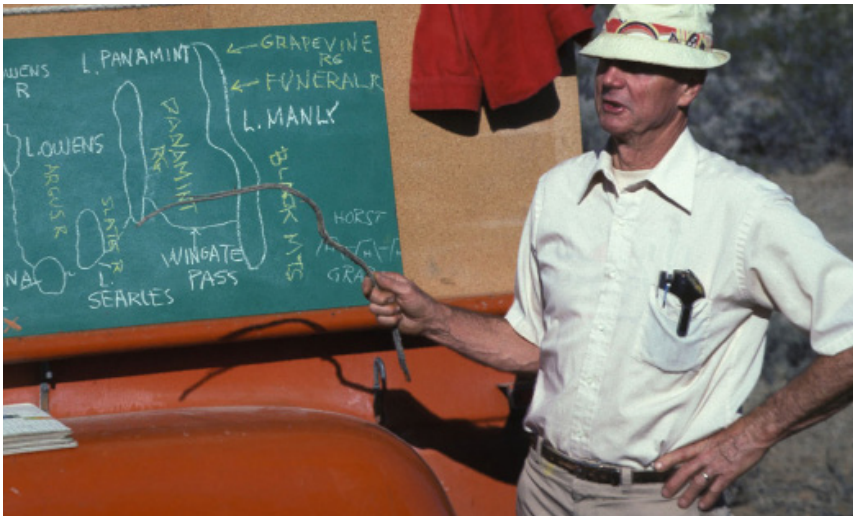
Probably UCSB students and his fellow faculty will best remember him for being a frequent and enthusiastic leader of department field trips, later Geology 18, to the mountains and deserts of southern California. These 4-5 day sojourns were real adventures, especially the one to the eastern Mojave Desert where, after climbing and experiencing the "singing dunes" of Kelso, the group would repair to "The Bunny Club", a unique desert cabin that Bob and brother Ken built among giant boulders in the Granite Mountains.

Bob Norris lived a long, full, and good life. He was a man of great dignity and heart who will long remembered by his family, students, and many friends. -- contributed by Art Sylvester

For another perspective, see: *tinyurl.com/9t2yenb*

*NOTE: A **Memorial Service for Bob** will be held on April 13 from 1-5 PM at UCSB. Please visit bobnorris.org to RSVP, upload photos, videos or remembrances, and check that website for emerging details.*

.. *Bob pointing the way forward*




*Bob explaining the Pleistocene "pluvial" lakes of eastern California*

# 2011-2012 Departmental Graduate Awards

**G.K. Gilbert Award**
John Moore
Amanda Willingham

**Harry Glicken Memorial Award**
Graham Hagen-Peter

**Richard and Eleanor Migues Graduate Field Research Award**
Stephanie Mendes

**George Tunell Endowed Fellowship**
Michael Stearns

**Wendell Woodring Memorial Award**
Leigh Anne Riedman

**Preston Cloud Memorial Award**
Jonathan Harvey, Graham Lederer, Jaron Lucero, Daniel Luna, Tess Mayall, Jesse Mosolf

**Lloyd and Mary Edwards Field Studies Fellowship**
Forrest Horton, Bryan Norman

**RV Fisher Award**
Daniel Luna, Rebecca Streit

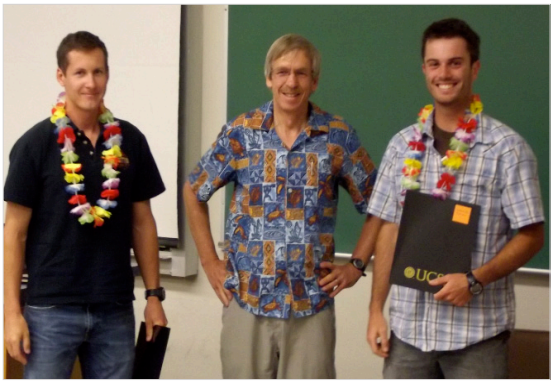
**Geophysics Award**
Xiangyu Li

**Alumni Graduate Award for Research Excellence**
Tess Mayall, Jeffrey Creamer

**Fugro West Award**
Qiming Liu

**Coast Geological Society Award**
Jessica Thompson

Cloud Award Recipients, 2012.



Forrest Horton and Bryan Norman are this year's recipients of the Lloyd and Mary Edwards Field Studies Fellowship

Undergraduate Award Recipients, 2012

Dept. Chair, Doug Burbank, presents the Bushnell Award to Jonathan Munnikhuis.

# 2011-2012 Departmental Undergraduate Awards

**William Bushnell Memorial Scholarship**
Jonathan Munnikhuis

**Robert M. Norris Prize in Field Geology**
Eryn Burkhart

**Outstanding Graduating Senior**
Kelli Johnson

**Outstanding Academic Achievement**
Eryn Burkhart, Camille Collett, Kathryn Fry, Kelli Johnson, Robert Maksimow, Luke Merrill, Lauren Mosley, Jonathan Munnikhuis, Jacob Poletti, James Proffitt, Brenna Quigley, Nathaniel Stover

**Distinction in the Major Award**
Camille Collett, Kathryn Fry, Robert Maksimow, Jonathan Munnikhuis, James Proffitt, Nathaniel Stover

**Charles Douglas Woodhouse Award**
James Proffitt

**Venoco Field Scholarship**
Camille Collett, Kathryn Fry

**Department Field Award**
Alejandro Flores, Beau Gentry, Connor Hansen, Michael Kenney, Mary Klink, Dominic Mariano, Evan Monroe, Jacob Poletti, Julian Stahl

**Coast Geological Society Award**
James Proffitt

**Undergraduate Leadership Award**
Connor Hansen

# DEPARTMENT HIGHLIGHTS

## Grad Career Pathways Panel

April 27th, 2012 marked a fortuitous alignment of events where the All Gaucho Reunion and the Department's Graduate Research Review coincided with what proves to become a new departmental tradition: the Earth Science Graduate Career Pathways Panel. Thanks to generous support from the Graduate Division, the organizers of the career panel sought out distinguished alumni of the Earth Science graduate program to relate their valuable experiences and to field questions from current graduate and undergraduate students considering careers in industry, education, consulting, and government.

Each of the four panelists brought their diverse professional backgrounds and unique perspective of their particular field of expertise. Rick Hoffman ('73) runs his own engineering geology business in Santa Barbara. Scott Hornafius ('84) represented careers in the hydrocarbon industry, drawing from his experience working for Mobil, founding Mega Energy, and operating as an independent consultant. Jan Schultz ('91) teaches at Santa Barbara Community College and addressed many students' questions about careers in education. Currently at the Environmental Protection Agency, Ken Davis ('03) works as an International Environmental Program Specialist focusing on international negotiations on mercury. Each panelist shared their personal career pathway, before opening up the floor for questions from the students filling Webb 1100. Many students were interested to hear how and why each panelist chose their career, and what the students can do now to prepare for a career in a specific field.

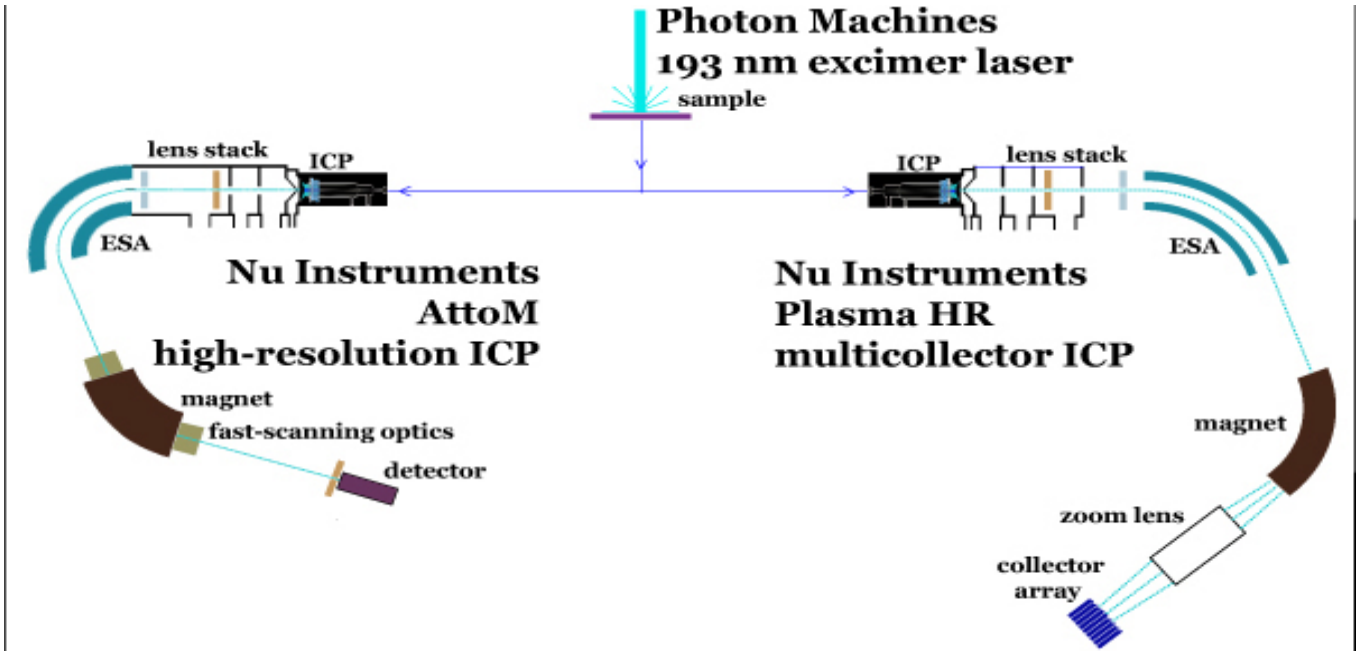
Alas, 90 minutes was far too little time to learn about exciting career opportunities from successful alumni. Fortunately, several students were able to accompany the panelists for a luncheon at the faculty club, followed by the Graduate Research Review in which all graduate students presented their ongoing research in a conference-style poster session. The rooftop patio was buzzing with conversations about "future work," in the sense of graduate students' projects and the promise of an exciting career. The response from students was overwhelmingly positive, with grads and undergrads unanimously voting in favor of holding a career panel each year, and shifting focus to disciplines that have not yet been represented. We plan to hold this event again next spring, and hopefully for years to come.

Contributed by the grad organizers: Graham Lederer, Jessica Thompson, Jon Harvey, and Forrest Horton.

## Laser-Ablation Split-Stream (LASS) Facility

***https://sites.google.com/site/icpgeolucsb/***

The UCSB laser-ablation split-stream (LASS) is a new Earth Science facility operated jointly by Andrew Kylander-Clark, John Cottle, and Bradley Hacker. It consists of four main instruments, two laser-ablation systems, a double-focusing single-collector 'AttoM' inductively coupled plasma mass spectrometer (ICPMS), and a double-focusing multi-collector 'Nu Plasma' ICPMS (depicted below). This facility is the first facility of its kind worldwide and continues UCSB earth science department's strong history in geochronology.

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# LASS Facility, *continued...*

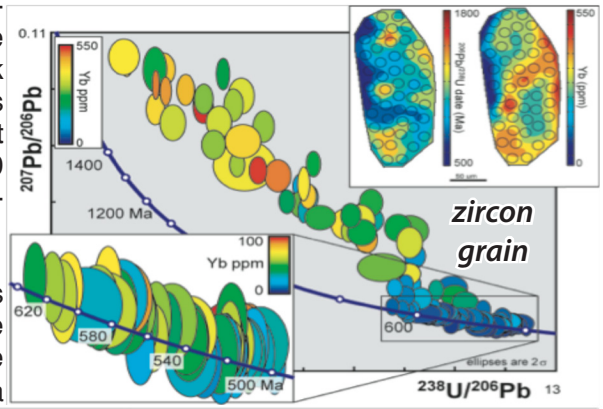
The lasers allow us to volatilize minerals in thin section at the 5- to 50-micron scale and, by splitting the material and sending a portion of the material to each mass spectrometer, we can simultaneously measure both the isotopic (age) and elemental composition of a wide variety of minerals.

The AttoM ICP employs state-of-the-art electronics to rapidly measure elements across the periodic table from 6Li to 238U, while the Nu Plasma can measure a narrower mass range, but to higher precision and accuracy. Much of the work that we do is devoted to simultaneous U/Th-Pb geochronology and trace-element analysis, but other kinds of analyses, like simultaneous U/Th-Pb and Hf isotopic analyses are also conducted.

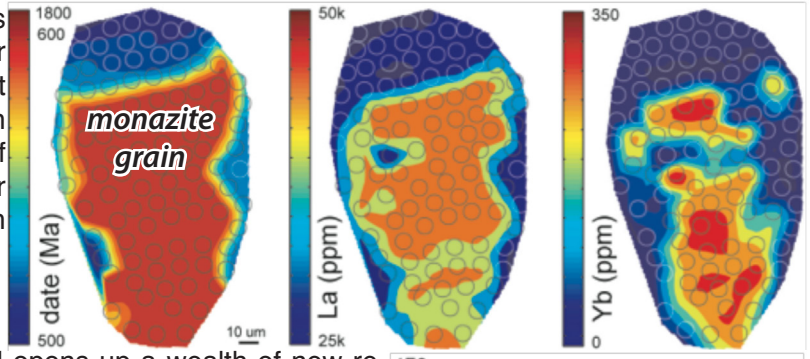
This facility enables us to link isotopic dates to specific geologic conditions such as pressure, temperature, mineral assemblage, or source characteristics. For example, we can assess what parts of a grain recrystallized at high pressure and when that recrystallization occurred; we can tie Hf or Nd isotopic signatures of mantle–crust differentiation events to specific times; we can quantify the temperatures at which certain parts of grains recrystallized; etc. What's especially exciting, novel, and powerful is that each analysis takes <30 seconds, so we can rapidly produce enormous datasets in which each date from a tiny spot in the grain is married to a petrologically informative composition. With such rapid throughput, we can quickly decipher complex geologic events that occurred over large regions; this ability is transforming our understanding of orogenic belts. Much of our emphasis has been on the U-Th/Pb age and trace-element compositions of zircon, monazite, titanite, and rutile. Current projects include:

- ultrahigh-pressure metamorphic rocks in Norway and the Himalaya;
- ultrahigh-temperature metamorphic rocks in Madagascar;
- deep-crustal rocks from the Pamir, Tibet, and Himalaya;
- magmatic systems in Antarctica; timing and source of rare earth element mineralization in southern California.

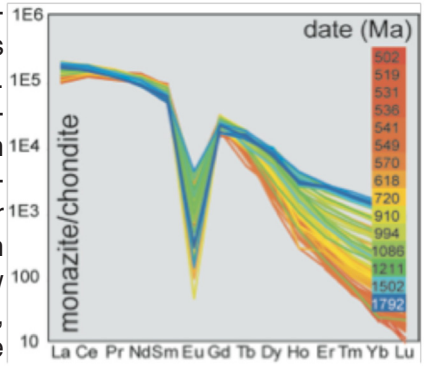
The figure to the right is just one example of how we apply this technique to zircon. From a single zircon grain (its age and Yb content are imaged in the upper right), we can determine that this particular rock is an upper Proterozoic sediment derived from 2.1–1.9 Ga sources (probably in east Africa) and that it was metamorphosed at garnet grade over a 110-Myr period beginning at 610 Ma and ending at 500 Ma. This type of analysis is well suited to understanding metamorphism, magmatism, and sedimentary processes.




Here's an example of how we apply this technique to monazite (its age, La, and Yb content are imaged in the upper panel). From a single grain from near the location of the zircon above, we can determine that this particular rock is an upper Proterozoic sediment deived from a garnet-free source as old as 1.8 Ga and that it was also metamorphosed at garnet grade over a 110-Myr period beginning at 610 Ma and ending at 500 Ma. It is the concentration of heavy rare-earth elements in particular that signifies the presence or absence of garnet; this distinction is depicted clearly in the lower panel, which shows older ages are correlated with heavy rare-earth element depletion.

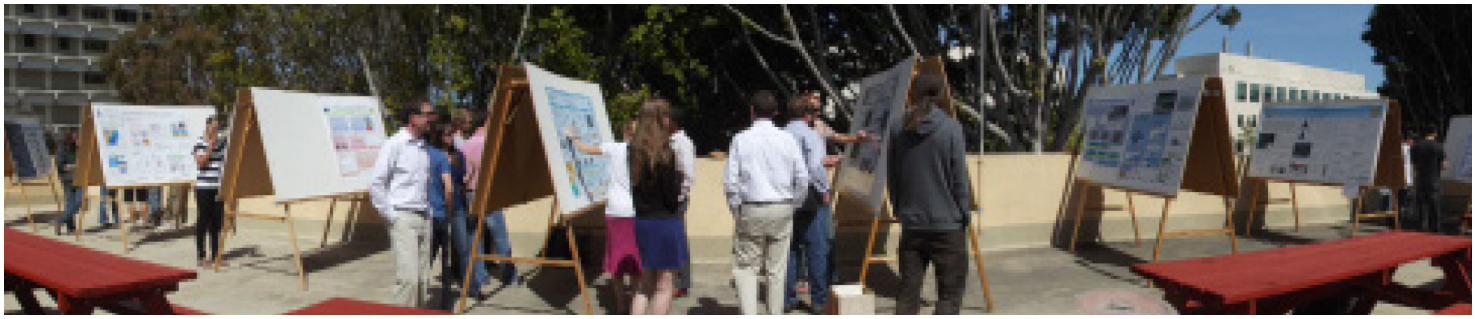



This facility puts UCSB at the cutting edge of modern geochronology and geochemistry research, and opens up a wealth of new research directions. It is exceptionally expensive to operate, however. The success of the entire operation depends on Dr. Andrew Kylander-Clark (UCSB PhD, 2008). Andrew provides technical expertise in laser ablation and mass spectrometry, student and visitor training in data acquisition and interpretation, scientific expertise in geochronology and geochemistry, and writes papers detailing our scientific achievements. His position is tenuous, however, in that we receive no financial support for his position. If you, as an alum, can help ensure the health of this facility—through either gifts to build an endowment for this facility or by letting your colleagues know about how this extraordinary facility can advance their goals—please do so. We, and all the undergraduate and graduate students who start their careers with these instruments, will do our best in return.



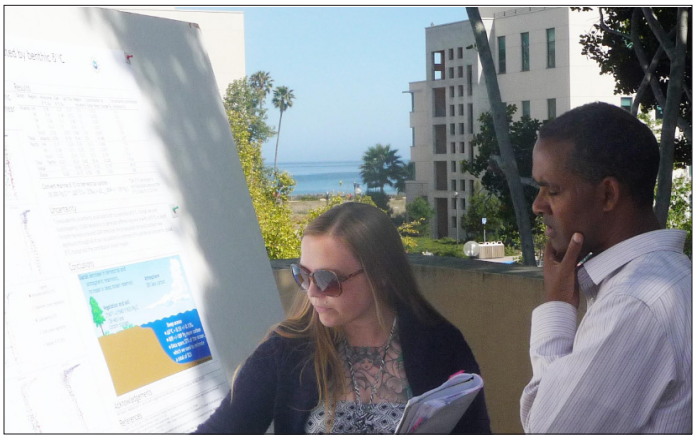
# Graduate Research Review

The annual Graduate Research Review (GRR) gives the graduate students the opportunity to showcase their research through a poster presentation. The Earth Science Department, alumni, friends, and other members of the UCSB community are all invited to this event.



A panoramic view of the rooftop as students set-up posters for the event.

Students of Prof. Jordan Clark, Stephanie Diaz and Timothy Becker, exchange viewpoints.



Grad student, Carlye Peterson with her faculty advisor, Prof. Syee Weldeab.

Second year grad student, Michael Stearns presents to a group of postdoctoral researchers.

A group of new grads are completely engaged in a conversation with senior grad student, Burch Fisher.

First-year grad student, Bryan Norman, is in deep thought as alum Robert Decesari (W'09) ask a question.

Attendees sit down and enjoy the bbq and beverages provided by the department.