UC DAVIS

EARTH AND PLANETARY SCIENCES

2015-2016 NEWSLETTER VOLUME 12

#EARTHQUAKE GEOLOGY

in this issue:

UCDAVIS
DEPARTMENT OF EARTH AND PLANETARY SCIENCES

on the cover: Napa Earthquake surface rupture moletrack through vineyard property adjacent to Buhman road.

UC Davis
Earth and Planetary Sciences
Newsletter, Volume 12

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CHAIR'S WELCOME

Dear Friends, Alumni, and Colleagues,

The Department of Earth and Planetary Sciences is continuing to thrive and build on its reputation for research and teaching excellence. UC Davis is ranked as having the highest impact of any university in life and earth sciences when both research output and quality are evaluated (**http://dateline.ucdavis.edu/dl_detail.lasso?id=15201&dn=060915**). In addition, our graduate program remains very highly ranked, and excellent students are choosing to study in our department. Our Geology, Natural Sciences, and Marine and Coastal Science majors remain strong and are continuing to grow.

I am very pleased to announce that Professor Nicholas Pinter has joined the Earth and Planetary Sciences faculty as the new Roy J. Shlemon Chair in Applied Geosciences. Nicholas is an expert in rivers and floodplains, with a background in geomorphology. His research spans policy development for floodplain land use to river flow history and evolution to geomorphic signatures of Quaternary geological processes. And very importantly for our students, he is continuing the Ecogeomorphology of Rivers and Streams course that Professor Jeff Mount supported with funds from the Shlemon Chair, providing students with intensive, multi-disciplinary fieldwork opportunities on ecologically important rivers.

Nicholas Pinter. His research focuses on earth-surface processes (geomorphology) applied to a broad range of problems.

Sarah Roeske in the Alaska Range.

Another major shift in our research program is a "change of hats" by Dr. Sarah Roeske. Sarah helped run and managed the Electron Microprobe Lab for 25 years, and she decided to retire from her staff position in 2015. She will remain active in research and teaching within Earth and Planetary Sciences, but we will be hiring a new scientist to manage the probe lab. We greatly appreciate Sarah's decades of service to the department and the broader community in maintaining an exceptionally high quality analytical facility that is a pleasure to use.

The UC-wide CalTeach/Math and Science Teaching (MAST) program remains under Earth and Planetary Sciences leadership with Professor Sandy Carlson taking over as faculty director after Professor Howard Day retired last year. We are also very excited to have a new science education leader join MAST: Susann Pinter. Susann comes to MAST with extensive teaching, teacher training, and pedagogical experience that complements the skills of Mary Betty Stevenson, who built the program with Howard over the past 5 years. Based on the outstanding success of MAST, the addition of Susann to the staff, and the desperate need for K-12 science teachers, we are hoping to raise significant foundation funds to allow the MAST program to expand over the next several years.

Congratulations to the Class of 2015

As you will read in the rest of the newsletter, Earth and Planetary Sciences researchers and students are performing exciting, state-of-the-art research spanning the globe. We provide both graduate and undergraduate students with special research opportunities in the field and in the lab, opportunities that prepare them for diverse careers. If you would like to help support these opportunities, please consider giving (https://give.ucdavis.edu/GELA) to the Cordell Durrell Fund, the Rand Schaal Field Fund, or the Robert Matthews Memorial Endowment. These funds are used exclusively to support student research and field experiences, and we greatly appreciate the ability to expand student participation in these activities through enhanced financial support.

■ ■ ■

Finally, I wish to thank each of you who have contributed to our successes by participating in our community and representing our department as you have moved on to the next phases in your careers. Please come by when you are in the neighborhood and send updates on your activities to geology@ucdavis.edu. Also, keep an eye out for at least two special alumni-focused events this year! We have some exciting new plans developing....

Cheers,

Dawn

Dawn Sumner

#Earthquake Geology in Napa Valley

"The culprit for the 2014 South Napa earthquake was the West Napa fault. As we later discovered, this is not the first time that this fault has damaged the wine industry."

– Mike Oskin

Featured Faculty Mike Oskin

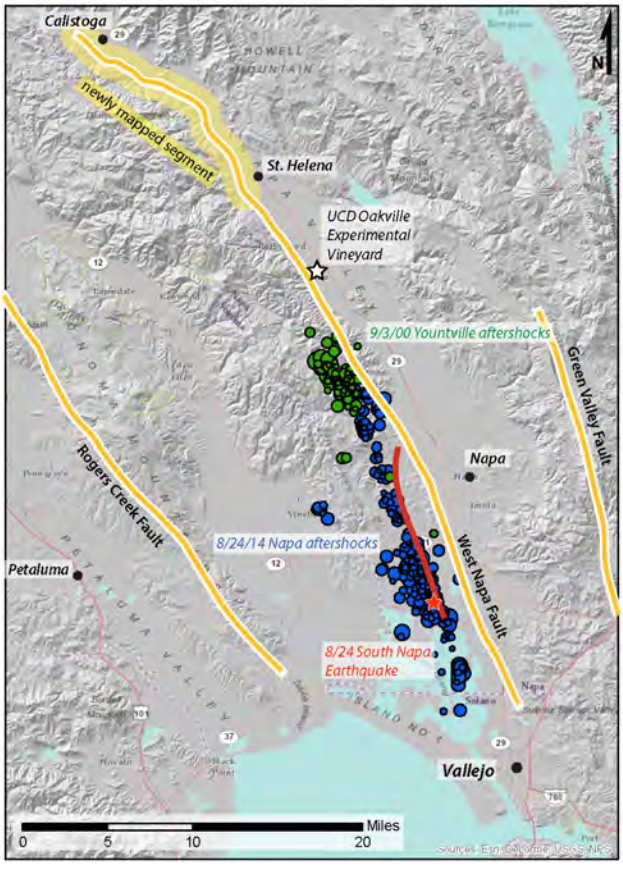
Much of the topography of California is related, in one way or another, to active tectonics. In my research, I try to understand the evolution of topography in order to determine recent geologic history, deduce patterns of uplift, and measure rates of fault slip. This project started out from a casual interest in earthquake hazards to our local, world-famous slice of wine country. The project accelerated after the 22 August 2014 M6.0 South Napa earthquake focused attention on this problem. What follows is the story of how UC Davis students, Dr. Louise Kellogg and I discovered evidence that active faulting occurs along the entire length of Napa Valley, and that the size and extent of potential earthquakes here has been underestimated. I also describe some of the ways that 3-D visualization, and in particular the UC Davis KeckCAVES, has helped us in making this and other discoveries following the 2014 earthquake.

■ ■ ■

The culprit for the 2014 South Napa earthquake was the West Napa fault. As we later discovered, this is not the first time that this fault has damaged the wine industry: the M5.0 2000 Yountville Earthquake likely occurred along the same structure. Like other valleys of the northern coast ranges, Napa Valley is elongated to the northwest, parallel to strike-slip faults of the right-lateral San Andreas system. The West Napa fault is likewise right-lateral, and it sits at the base of the Mayacamas mountains, west of the city of Napa. Is there a component of uplift responsible for these mountains? Oddly, the West Napa fault was mapped as terminating about halfway up the valley. What happens north of this termination? Geophysical data suggests a steep boundary on the western side of the basin here, but does not elucidate its origin.

■ ■ ■

I began my research by poring over a 2003 lidar survey that was collected for analysis of fish habitat in Napa Valley. Using the dynamic hillshading feature of the KeckCAVES LidarViewer point-cloud visualization software, I discovered a pair of subtle topographic features in the northern part of the valley, between St. Helena and Calistoga, that looked suspicious: a set of narrow topographic benches lined the southwest margin of the valley, at the base of the Mayacamas mountains, and an alignment of low-amplitude hills occupied the center of the valley, adjacent to the Napa River. Follow-up mapping by UC Davis undergraduate Savannah Lisle, and field trips in March of 2014, confirmed that the topographic benches were produced by repeated slip events on a reverse fault, and that



Simplifed map of the West Napa Fault, 2014 earthquake surface rupture, and aftershocks from 2000 and 2014 events.

the hills were comprised of folded river gravel deposits. That May I submitted a proposal to the U.S. Geological Survey to study these features. This proposal would seem prescient a few months later.

I was not in Davis on August 22, the morning of the South Napa earthquake. In southern California, visiting family, I would learn of the event about 5 hours later. The existence of surface rupture was not yet confirmed, so I immediately began to scour the web for reports of road damage, and Twitter for photographs. These revealed right-lateral offset of Highway 121/12, west of Napa, coincident with one strand of the West Napa fault. So I broadcast an email to the UC Davis structural geology group to offer my field vehicle for earthquake field response. Alex Morelan and Chad Trexler jumped on the opportunity and headed to the field later that morning.

Alex, Chad, and I worked together as a team that day, communicating by text and picture messages. As Alex and Chad collected slip observations, I compiled a map in Google Earth and directed them to unexplored sites along strike of the rupture. As the extent of faulting became clear, I also began broadcasting our findings on Twitter. By the end of the day, news media nationwide was following our feed for the latest information on the earthquake rupture. This team approach, with one member working remotely, turned out to be a highly effective way to cover ground quickly and make key, early observations before offset features were destroyed by repair crews, and before much post-earthquake fault creep had accrued. The results of this effort were published in *Seismological Research Letters* in May 2015.

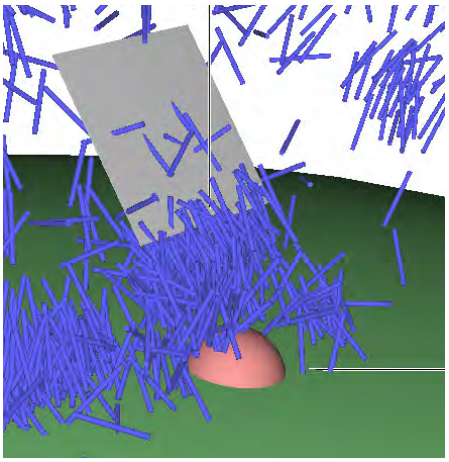
Rupture across South Avenue and adjacent vineyard. Grad student Chad Trexler for scale.

Napa Valley Grist Mill historic site is built across 2m-high scarp of West Napa fault.

Nine UC Davis graduate students participated in a follow-up special studies course co-taught by Dr. Louise Kellogg and I. The entire class mapped the northern part of the fault in the field where it is expressed in Bothe-Napa State Park. Alex Morelan and Chad Trexler used a new photogrammetric technique, known as Structure-from-Motion, to build 3-D point clouds of offset features from overlapping digital photos. By preserving the 3-D geometry of features, this technique enables reproducible post-earthquake measurements using a virtual environment such as the KeckCAVES. Of course they use LidarViewer to make these measurements. Angela Hawkins showed that the aftershocks of the 2000 Yountville event lined up with those from 2014, consistent with a single, larger earthquake source. Mary Barr and Justin Linderman used this information, along with our mapping, to generate a 3-D model for the greater West Napa fault, and to estimate Coulomb stress change on segments that did not rupture in 2014. Based on its size, the West Napa fault is capable of producing a ~M7 earthquake if it ruptured from end to end. This would be over 30 times the energy released in the 2014 event, and it would affect the entire length of Napa Valley.

EARTH AND PLANETARY SCIENCES FACULTY

Magali Billen. This year I returned to my old stomping grounds, the Tonga-Kermadece Subduction Zone. Working with student John Bikoba (M.S. 2015), we identified some interesting features in the deep earthquakes (>400 km deep) and in the orientation of stress in the subducting slab inferred from the earthquake moment tensor solutions. Based on our analysis, we concluded that one of the features may be the result of a small-scale plume rising up, directly beneath the slab. The buoyant plume causes the slab to bend upwards creating a gap in seismicity and tearing of the slab (see figure). The next step will be to create simple geodynamical simulations to test if our interpretations are correct, and to gain more insight on the temperature anomaly and size of the plume as well as the strength of the slab.

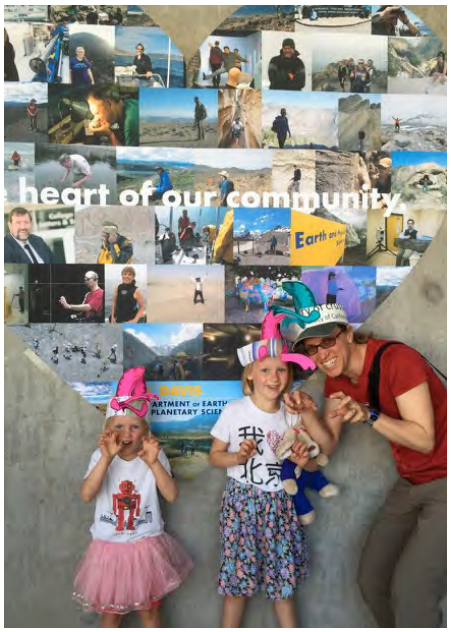


Cathy Busby. Professor Emerita (UC Santa Barbara) on recall as Research Scientist at UC Davis. She has brought postdoctoral researcher Sarah Medynski (France) with her to UC Davis. Sarah is supported in Cathy's NSF award to study a Cretaceous oceanic island arc terrane in Baja California, comparing it to the Izu-Bonin arc, where Cathy was IODP Co-Chief Scientist last year. Cathy has also been writing up results and getting lab data from that expedition, supported by IODP awards. In addition, Cathy recruited two new Ph.D. students this fall. Abdullah Wahbi (M.S., Saudi Arabia) is working on basin analysis of the Santa Rosalia rift basin in the Gulf of California, supported by Cathy's NSF-REU (Research Experience for Undergraduates) award, and by Aramco. Catherine Wesolowski (B.S., UNC-Chapel Hill) is doing research on Walker Lane transtensional faulting and volcanism in the Sierra Nevada range front of California.

Sandy at the Museum National d'Histoire Naturelle in Paris.

Sandy Carlson. Research on brachiopod morphology, ontogeny, and phylogeny continues with my Ph.D. student Natalia Lopez Carranza, and post-docs Holly Schreiber and Dave Bapst. We are currently preparing two manuscripts to submit for publication, and we presented talks on this research at the Annual GSA meeting in Baltimore in November 2015. We also welcomed new Ph.D. student Tristan Eversole to the wonderful world of brachiopod evolution studies in the fall. I recently submitted an NSF proposal to work with new Stanford faculty member Erik Sperling to embark on phylogenomic studies of living brachiopods, in order to better understand their relationship to other metazoans, and their interesting mineralization history. I continue to serve as the Past-President of the Paleontological Society (PS), chairing the PS Medal and the Schuchert Award committees, which are two of the main awards given by the society each year for excellence in scholarship in paleontology. In October 2014, I agreed to become the Interim Director of the UC Davis CalTeach/MAST (Mathematics and Science Teaching) program, following the retirement of founding director Howard Day. The CalTeach/MAST program is designed for undergraduate STEM majors who would like to explore career options in K-12 education. CalTeach/MAST offers coursework to introduce students to teaching at the elementary, middle school, or high school levels, and each course is accompanied by an in-classroom internship that provides them with valuable field experience. All these activities have kept me quite busy, in addition to sending our youngest off to college this fall, preceded by a family trip to Europe, which included a visit to the Museum National d'Histoire Naturelle in Paris.

Kari Cooper. This past year included a lot of travel for talks and conferences and data collection, but not a lot of field time! Starting in Fall 2014, I gave presentations at GSA (pre-conference short course) in October, a talk at UCSB in November, AGU in December, a Gordon conference in June 2015,



Kari and her daughters Simone (left) and Katja get into the spirit of dino hats on Picnic Day!

Eric in Northwest China along the Altyn Tagh fault.

and the Goldschmidt geochemistry conference in Prague in August. In between preparing for and traveling to give talks, I have been working with my graduate students on further exploration of the thermal conditions of magma storage, including Kevin Schrecengost's Ph.D. work on Lassen Volcanic Center, Pinatubo, Mount St. Helens, and Volcan Quizapu, Chile. Allie Rubin continued to explore similar topics at the Taupo Volcanic Zone, including collecting piles of data, submitting her first manuscript for publication, and with a second in the works. M.S. student David Houchins continues to work on his thesis on developing carbonate dating, and plans to finish in fall quarter. I am looking forward in the coming year to a lot of progress on these projects, and perhaps a slightly less insane travel schedule!

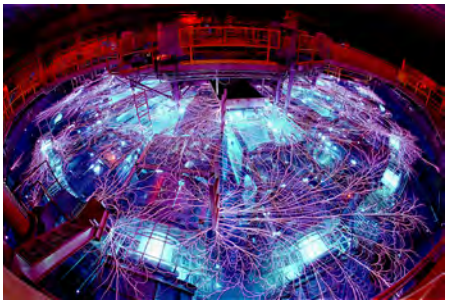
Eric Cowgill. My research uses geologic observations to quantify the deformational response of the continental crust to plate collision. One main focus is on the Cenozoic evolution of the Greater Caucasus, in the Arabia-Eurasia collision zone with Ph.D. student Chad Trexler. In the last year we've secured NSF funding for field work in Georgia and Azerbaijan to identify the first-order structures within the Caucasus and to quantify the magnitude and timing of late Cenozoic shortening; we're testing the idea that the range results from subduction of a relict backarc basin, followed by slab breakoff beneath the western half of the range. A second main focus has been a NSF-supported project to test for possible changes in slip rate over time along the Mojave section of the San Andreas fault. Mary Barr is finishing a nice M.S. thesis on 3 slip-rate sites, and new M.S. student Elaine Young will continue the project. A third main focus is determining the mechanisms and history of plateau uplift along the Altyn Tagh fault and the NW margin of Tibet. In Fall 2014, I conducted fieldwork in North Western China with Mike Oskin and M.S. student John McDermott and have since used (U-Th)/He apatite low-temperature thermochronology and analysis of industry seismic data to quantify the magnitude and timing of shortening along the North Altyn fault.

Tessa Hill. I'm happy to say it has been a busy and productive year in the Hill Lab. My work continues to focus on the impacts of climate change and ocean acidification, in past and modern environments. My students and I are working on culturing foraminifera under future conditions, understanding the impacts of climate and oxygenation change in marine ecosystems, and investigating the impact of ocean acidification on the California coast. For fieldwork, we've been quite busy with plankton towns, research cruises, and instrument deployments offshore Bodega Head, in Tomales Bay, in Bodega Harbor, and as far south as Catalina Island. I was fortunate enough to give an invited talk at the AAAS national meeting, and join a Kavli Frontiers of Science group that traveled to Israel in February 2015. Ph.D. student Sarah Moffitt graduated and took a postdoc position at the University of Washington; Jessica Hosfelt is finishing up her M.S. thesis as I type. Continuing students include Kate Davis (Ph.D.) and Brady O'Donnell (M.S.), joined in the lab by postdoctoral scholar Dr. Emily Rivest. We continue to work closely with the UC Davis CalTeach/Mathematics and Science Teaching (MAST) program to develop 6th grade curriculum focused on climate change for local schools. For more information, please visit:
http://hillbiogeochemistry.squarespace.com

Sarah Roeske. I am changing hats! Better stated, taking off one hat, leaving a couple others on. As of September 1, 2015, I stepped out of the electron microprobe lab and will no longer be lab manager or otherwise officially involved. I am looking forward instead to using the microprobe for my own imaging and chemical analyses. This change means more time for research, advising students, planning and leading field trips, and other fun. The past year was busy with preparing for this change and the microprobe lab should continue smooth sailing within the department. Thanks go to our Chair, Dawn Sumner, for helping find a way to hire another lab manager (a work in progress!).

Sarah and her rainbow boot.

The summer brought a chance for a short field season along the Denali fault, back to a locale that has proved particularly good for exposure of the ductile part of a strike-slip fault system. Sadly, the trusty field boots purchased 5 years ago for this project finally gave out and delaminated completely on one foot. Fortunately, duct tape to the rescue! in rainbow colors that complimented my field attire. The photo was taken by Laura Tait, my M.S. student who is studying the ductile fabrics in the fault zone.



Z Machine: Arcs and Sparks by Randy Montoya.

Sarah Stewart studies planet formation and evolution with an emphasis on collisional processes. Shock physics studies of natural materials are essential for a wide range of problems in Earth and Planetary Sciences, including planetary accretion and disruption, impact crater formation, high-pressure states in planetary interiors, and the interpretation of astronomical observations of collisions in exoplanetary systems. Her experimental program will be based in the new Shock Compression Laboratory at UC Davis. The facility will have 2 light gas guns capable of launching 100-g projectiles up to 8 km/s to recreate the pressure and temperature conditions encountered during planet formation. Construction is underway and the lab will be ready in early 2016.

In an experimental study led by Sarah Stewart's former graduate student, Dr. Richard Kraus, we determined the impact velocity needed to vaporize iron. Iron is one of the most common elements in planets, but its thermodynamic properties are not known at the very high pressures and temperatures reached during planetary impact events. Using the Sandia Z Machine to launch aluminum flyer plates faster than 20 kilometers per second, we measured the shock and post-shock densities of iron. By comparing the post-shock densities to the density of liquid iron at the boiling point, we determined the impact conditions needed to vaporize iron. The impact pressures required to vaporize iron are much lower than previously thought and impact-induced vaporization was a common process during the end stages of planet formation. This work was published in Nature Geoscience last summer.

Reference: Kraus, Richard G., et al. "Impact vaporization of planetesimal cores in the late stages of planet formation." Nature Geoscience *(2015).*

The Z machine is part of the Pulsed Power Program at Sandia National Laboratories. Pulsed power is a technology that concentrates electrical energy and turns it into short pulses of enormous power. This energy is used to launch aluminum projectiles up to speeds of 40 kilometers per second (about 90,000 miles per hour). For comparison, Earth orbits the Sun at a speed of about 67,000 mph. Professor Stewart's group was selected to conduct Fundamental Science Experiments related to Earth's formation at the Z machine.

Geerat Vermeij. The highlight of the last academic year was a megatrip to the Netherlands, England, and Argentina. In the Netherlands, I took part in a formal evaluation of Naturalis, the Dutch national museum of natural history, with which I have had a close association. In England, I gave a plenary lecture on limits to evolution in a conference organized by Simon Conway Morris at Cambridge. In Mendoza, Argentina, I gave another plenary lecture for the Fourth Annual Paleontological Congress; but the real highlight came during a post-conference field trip to Patagonia. I have never before seen such enormous beds of giant fossil oysters, stretching for hundreds of kilometers. Incredibly dry and desolate Patagonia nonetheless also has some wonderful natural history, from massive colonies of parrots on the shore to guanacos, elephant seals, and desert plants.

Robert Zierenberg. Research on Icelandic geothermal systems continues in our labs, and several new drilling projects are on the horizon for next year. However, in

Geerat at a fossil oyster reef near Puerto Pirámide, Argentina.

the last year I was able to return to my previous research area, the investigation of seafloor hydrothermal vents. Thanks to an invitation from my long-term research colleague, David Clague, I was able to participate in a research cruise on the ship Western Flyer operated by the Monterey Bay Aquarium Research Institute (MBARI). We used the Remote Operated Vehicle (ROV), ***Doc Ricketts***, to investigate the Alarcon Rise, the northern-most spreading segment of the East Pacific Rise, off of the tip of Baja California. One of the objectives of the cruise was to map the extent of, and sample, a sequence of highly differentiated volcanic rocks formed at the spreading center. This spreading center is unique in that we find basalt, andesite, dacite and high silica rhyolite flows erupted at the ridge crest. My primary responsibility on the cruise was to collect hydrothermal fluids from black smoker vents. We located three new vent fields, with temperatures up to 365°C. One of the vent fields was particularly impressive with some

An unusual vent field in the Pescadero Basin.

chimneys towering more than 30 meters above the seafloor. An unusual vent field was discovered at 3750 m water depth in the Pescadero Basin, a small sediment buried pull apart basin at the opening of the Gulf of California. This area had large mounds (200 m in diameter and up to 75 m high) of hydrothermal material, indicating it has been active for a very long time. The active vents have clear shimmering water (290°C) and are precipitating coarse crystalline calcite. More information on the cruise is available on the MBARI website: http://www.mbari.org/news/news_releases/2015/pescadero/pescadero-release.html

VISITING FACULTY

Sarah Lambart. Being new in the Department, I'm excited to share my research. I'm an experimental petrologist who is trying to understand the role and contributions of the pyroxenite melts during the formation of oceanic basalt. Pyroxenites are relatively rare mantle rocks that could significantly contribute to formation of the oceanic floor.

I also collaborate with colleagues at Lamont-Doherty Earth Observatory. We are working on delimiting the optimal conditions for in situ carbon mineralization, a storage technique that consists of transforming the CO_2 into stable minerals (carbonate). We used experimental methods as well as field trip observations to understand this naturally occurring process.

Sarah standing on the Falljökull glacier, Iceland.

GRAD STUDENT NEWS

Mary Barr. The work that I completed towards my Master's degree provided age and offset data for three newly identified deflected and beheaded channels along the northern Mojave San Andreas Fault in southern California. The goal of my work is to illustrate the complexities of determining age and offset measurements from fluvial systems for slip rate estimates and demonstrate some of the sources of large uncertainties for age and offset data. My work focused on the timing and character of the geomorphic and neotectonic events that shaped each of the three fluvial systems.

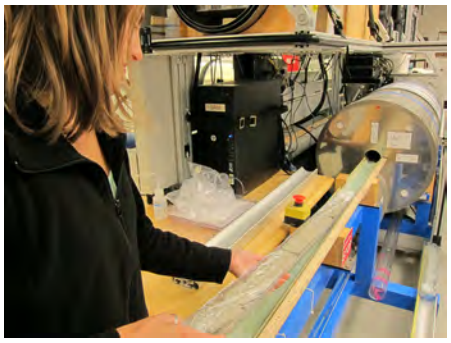
Mary (left) and Dr. Kate Scharer, USGS Pasadena (right).

Andrew Fowler. I study water-rock interaction in the Reykjanes Geothermal System, Iceland, located on the immediate on-shore extension of the Mid Atlantic Ridge. I study the chemistry of drill core and hydrothermal fluid samples recovered by the Iceland Deep Drilling Project (IDDP). The IDDP aims to drill ~5 km deep and harness super-critical fluid for geothermal energy production. Supercritical fluids could increase the

Andrew standing where the submarine Reykjanes Ridge comes onshore.

energy output of a single geothermal well by a factor of ten, revolutionizing geothermal energy production. I investigate trace element changes in rocks and fluids to understand chemical processes that will 1) inform geothermal fluid production and 2) make comparisons with this important Mid-Ocean Ridge analog.

At the end of September 2015, **Millie Levin**, a Masters student studying with Professor Ken Verosub, concluded an eight-week cruise on the Joides Resolution, the drilling ship of the International Ocean Discovery Program. Millie served as a paleomagnetist on Expedition 356: Indonesian Throughflow. She helped develop a magnetostratigraphic framework for more than 5 km of marine sediments from Australia's North Western Shelf. The goal of the cruise was to study the timing and variability of flows from the Indonesian warm pool into the eastern Indian Ocean as well as climate change and subsidence of Australia. Millie's post-cruise environmental magnetism research will also contribute to these scientific objectives.



Millie onboard the Joides Resolution.

IN MEMORIAM: RAND SCHAAL

Remembering Rand, 1951-2015

Rand Schaal stands in front of his home-built Jabiru Light Sport Airplane, named "Sheila".

Dear Friends and Members of Earth and Planetary Sciences,

The UC Davis Department of Earth and Planetary Sciences—and the greater geology family—has lost a good friend. Rand Schaal unexpectedly and peacefully passed away overnight September 10-11, 2015 in Needles, California. He was traveling between his homes in Davis and Arizona.

For those of us who had the great fortune to know and work with Rand, this is sad news indeed. Rand was a beloved member of our Department, receiving his B.S. in 1973 and Ph.D. in 1991, both in geology. After completing his doctoral degree, he became a celebrated teacher, specializing in general education courses that inspired and entertained thousands of undergraduates. His students—who adored him—bestowed on him the nickname "Moondude" for his love for planetary geology: a moniker he enjoyed greatly.

A legacy of Rand's commitment to teaching is present on campus—the Ted and Rand Schaal Auditorium in Warren and Leta Giedt Hall. Rand and his father donated the resources to equip this room to teach geology. Department members teach hundreds of students to think scientifically in this classroom every year.

Rand also knew what all geologists know—the spark in understanding and appreciation of the earth sciences lies in the field. To that end, he created the Rand Schaal Field Fund, challenging alumni to match his contributions to support the Department's efforts to get students into the field. That fund has supported many undergraduate and graduate students in their fieldwork over many years.

Rand and his father were also generous contributors to the campus. Rand was an avid, perhaps even obsessed, competitive swimmer. This passion for swimming and UC Davis led to a major gift to the campus to build the Ted and Rand Schaal Aquatics Center, which is used today by countless numbers of students.

While Rand was generous in his support for the Department and campus, he will be most remembered for his generosity of spirit. If you met Rand, you met a friend. He always greeted you with a smile, a warm heart, and a goofy joke. This sense of fun persists in Rand's fiction; he finished writing and self-published "The Radon Trilogy" in August of this year, which features characters based on his friends. And if you had the great luck to spend time with him—especially flying around in his several planes—you always came away feeling great. That was Rand's special gift to all of us.

The Department sends its condolences to Rand's family—his sister Connie and his father Ted and all who called him a friend.

Sincerely,
Dawn Sumner

PS: If you wish to share memories about Rand with his geological community, please send them to memories-of-rand@ucdavis.edu. If you wish to be notified of information related to Rand, including memorials, please send a request to **memories-of-rand@ucdavis.edu**. A web page has been established at **http://geology.ucdavis.edu/people/inmemoriam/schaal**

Rand enjoyed flying over the Davis campus, and he shared many of his aerial photographs with the department. Clockwise from left: the Earth and Physical Sciences building (under construction at the time); Warren and Leta Giedt Hall; the Ted and Rand Schaal Aquatics Center; Rand in the cockpit, flying over UC Davis.

UC Davis CalTeach/Mathematics and Science Teaching Program

The UC Davis CalTeach/Mathematics and Science Teaching program (MAST) resides within the Department of Earth and Planetary Sciences.

Launched in 2005 by the University of California, CalTeach programs exist on each UC campus, and were created to help address the challenges posed by significant decreases in the number of people pursuing teaching credentials, particularly in STEM (science, technology, engineering, and mathematics) fields.

Professor Sandy Carlson serves as the Faculty Director of CalTeach/MAST at UC Davis, which is designed for talented undergraduate STEM majors who would like to explore career options in K-12 education in STEM fields. CalTeach/MAST staff members — Academic Coordinators Mary-Betty Stevenson and Susann Pinter, as well as Lecturers Charlie Horn, Kathlan Latimer and Al Mendle — offer advice and mentoring to help STEM undergraduates keep their career options open to the possibility of K-12 teaching as they complete the coursework required for their degree. CalTeach/MAST offers coursework to introduce undergraduate students to teaching at the elementary, middle school, or high school level; each course is accompanied by an in-classroom internship that provides them with valuable field experience working directly with K-12 students. CalTeach/MAST started a successful Learning Assistant program, in which qualified undergraduates can serve as assistants to graduate Teaching Assistants (TAs) in selected STEM courses, mutually benefitting the undergraduates and the TAs.

The CalTeach/MAST program receives funding from a National Science Foundation Robert Noyce Track I grant, which provides scholarships to qualified undergraduate as well as graduate credential students in the UC Davis School of Education, and requires a significant commitment of classroom teaching experience in high-needs schools in California.

Anyone wishing more information about the program can consult our website (**http://mast.ucdavis.edu**) or contact the CalTeach/MAST program office at (530) 754-9621.

Your charitable, tax-deductible gift to the UC Davis Department of Earth and Planetary Sciences is greatly needed and appreciated. Your donation will be used to support the highest priority projects in the department: our undergraduate and graduate geology students, departmental programs and facilities.

Donate online by visiting the UC Davis secure giving site at:
https://give.ucdavis.edu/GELA

You may chose to donate to one of seven funds:

- **Geology General Support**
- **Geology Graduate Student Support**
- **Cordell Durrell Field Geology Fund**
- **Earth and Physical Sciences Building Educational Enhancement Fund**
- **Moores Distinguished Speakers Series**
- **Rand Schaal Field Fund**
- **Robert Matthews Memorial Endowment**

We especially appreciate unrestricted donations to the Geology General Support Fund, which provides the department with flexibility to support our highest annual priority projects.

Thank you for your support!

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Geology 138 Hawaii Volcanoes class standing on the rim of a collapsed volcanic cone on the SW rift zone of Kilauea volcano, Pu'ukoa'e spatter cone in the distance.