

Earth & Planetary **TIMES**

HARVARD UNIVERSITY DEPARTMENT OF EARTH AND PLANETARY SCIENCES



Blake Hodgin G3 kneeling on Paleozoic strata near Ayaviri in Perú's Altiplano.

The Odyssey of the Arequipa Terrane

Exploring ancient sutures in the Central Andes

BY BLAKE HODGIN, THIRD-YEAR GRADUATE STUDENT

Coastal southern Perú is inhabited by penguins, condors, and wild guanacos. However, what brings me there every summer is not the exotic wildlife, but exotic terranes—far-travelled crustal blocks that have been sutured from one plate to another at subduction zones. The suture of an exotic terrane, which represents the closure of an ancient seaway or ocean, may be a wide zone containing slivers of oceanic crust or it may be a cryptic fault between similar metamorphic rocks. In Perú, these sutures are often inaccessible, buried by kilometers of sedimentation and volcanism associated with recent growth of the Andes. The basement of southern Perú has nevertheless been identified as exotic to South America based on its older age and unique crustal signatures. Further study of this important crustal block, known as the Arequipa terrane, gives us an

opportunity to locate and unstitch sutures, reopen oceans, reconstruct ancient geographies, and test hypotheses about Earth's dynamic tectonic history.

When you open a folded geological map of South America, you can see belts of accreted terranes at the core of the South American craton. This is true of the cratons at the heart of the oldest continents such as Australia, Africa, and North America. There appears to be no vestige of a beginning to this important tectonic process of terrane accretion that continues today at plate boundaries on the margins of continents. To better understand terrane formation and accretion, I have chosen to focus on the unresolved history of the Arequipa terrane, which may also give us insight into the over-thickened crust of the Altiplano and modern mountain-building processes in the Central Andes. It's an exciting area

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With this issue, Earth & Planetary Times introduces a new column called "I Remember When" featuring stories from our readers about their time in the department. In the first article, on page 26, Bob Kamilli PhD '76 recounts the annual tradition of St. Barbara's Day, as celebrated in the 1970s. In the next issue, we'll feature the Geo Club, which, rumor has it, will be celebrating its 100th anniversary in 2018. If you have a Geo Club story to share, or if you have a suggestion for a future theme, please send it along to epsnl@fas.harvard.edu.

FROM THE CHAIR JOHN H. SHAW



Donning Hawaiian shirts, EPS concentrators bring a bit of tropical street attitude during this year's department field trip to the Big Island. See page 17 for more.

As spring arrives in Cambridge and the Harvard grounds are put in shape for Commencement, we turn our attention to delivering another issue of *Earth & Planetary Times*. The 2016–17 academic year has been wonderful, yet presented many challenges.

Issues on the national stage have raised important questions about inclusivity and the future of support for climate and environmental sciences—as well as scholarship more generally. We have responded with focus on our central strength: the ability to support an exceptional, diverse, and highly engaged community of students and scholars that comprise the EPS Department. The past year has seen the promotion of Francis Macdonald to full professor with tenure and the return of John Holdren to our faculty after serving eight years as President Obama's science advisor. We are also heavily engaged in renovations of labs for Rebecca Fischer and Roger Fu, who will be starting as new junior faculty on July 1, and of a new shared area in the Geological Museum for faculty, students, and staff in the geology, geobiology, and Earth history programs. Finally, we remain highly committed to our most important function: supporting the growth and development of new generations of graduate and undergraduate students, as well as other early-career scholars. Many are set to matriculate this spring and move toward promising futures in a remarkably broad range of pursuits. I hope you enjoy reading about all of these happenings in this issue of *Earth & Planetary Times*.

Also, please keep us posted of your whereabouts and activities so we can include you in the next issue!

Harry C. Dudley Professor of Structural & Economic Geology | Harvard College Professor | Chair EPS

Letters to the Editor

I was saddened to read of Adam Dzięwoński's death in the spring 2016 issue.

I was one of Adam's teaching fellows for Science A-24 between 1979 and 1983.

I learned a great deal of geophysics from Adam during that period. We also had a lot of fun! Even though my specialty was paleontology, I spent countless hours hanging out in Joe Steim's ('78, AM '82, PhD '86) lab. Adam was always in the area as well. As devoted as he was to his research, Adam always had a few minutes to talk. He had a warm personality and very good sense of humor. A number of years ago, my wife and I visited Adam and Sybil at their home in Harvard. Always gracious, we spent a wonderful afternoon together. Over the years, I continued to follow Adam's career and was always thrilled when I read the news of a new award or honor.

Each time we taught Science A-24, the teaching fellows arranged a field experience for the students. More conversant with computers than with rocks, Adam nonetheless always participated with enthusiasm. Although we tried, we were never able to convert Adam into a field geologist. That's probably just as well. Geophysics needed him more.

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Spring 2017 Volume 5

Published by the
Department of Earth and Planetary Sciences
Harvard University
20 Oxford Street, Cambridge, MA 02138
Phone: 617-384-9760 • Fax: 617-495-8839
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Editor: Chenoweth Moffatt
Contributing Editor: Cathy Armer
Designer: Vera Leung

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to be doing field geology because there are geological units that have never been studied.

The prevailing hypothesis that I am testing in the Central Andes is that the Arequipa terrane originated from what is now eastern North America. In this model, eastern North America and western South America collided with each other about a billion years ago in the making of the supercontinent Rodinia. Then, several hundred million years later, in the next stage of the supercontinent cycle, the two continents rifted apart. The Arequipa terrane is interpreted as a continental fragment caught in between and passed back and forth between its two parent continents: North America and South America.

To conceptualize this model, try doing the “detachable thumb trick”: Start by making a fist with both hands out in front of you. Pretend that you’re looking down on Earth, with the back of your clenched left hand as North America positioned above your clenched right hand as South America. The Appalachians should be your left thumb and the Andes should be your right thumb. Now, traveling back in time to the Precambrian, allow your hands to drift anticlockwise. Once your thumbs are side by side, mash your fists together in a continent—continent collision. After making it look like one of your thumbs is jammed into the other fist, dramatically pull your fists apart leaving the stranded tip of a thumb behind. Allow your hands to drift back to their original positions and—voilà!—you have more or less re-created the widely accepted model explaining the origin of the Arequipa terrane.

The falsification of this scenario would not only give you your thumb back, but it would have implications on the configuration of the Precambrian supercontinent Rodinia as well as the tectonic history of North and South America. An alternative hypothesis that has presented itself after a couple seasons of fieldwork in the Central Andes can also be conceptualized with your hands, but you can do it by putting North America—your left hand—in your pocket. Just hold your right hand out in front of you. Your right thumb is the Arequipa terrane, where it currently resides in the Central

Andes of South America. But imagine that your thumb starts off on the inside of your right elbow. Then, it slides along the inside of your forearm until it reaches your right hand, where it gets sutured into place. This scenario involving the lateral translation of terranes along a strike-slip margin is analogous to the modern tectonic setting of the San Andreas fault in southern California.

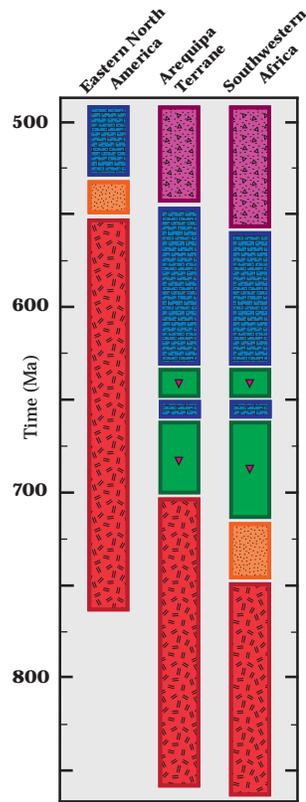
Because many of the structures associated with terrane accretion have been many times reactivated and/or buried by recent tectonic activity, my work in Perú has focused on exposures of the oldest sedimentary rocks. By establishing the age and provenance of these strata, I am developing a stratigraphic framework for interpreting the tectonic history of the Arequipa terrane.

Determining the age of the sedimentary rocks is critical for establishing links to tectonic events and to correlative strata on other continents and terranes. I use a variety of methods to determine the age of key units. I date them using the U-Pb radioactive decay system in minerals such as zircon and sphene. I also measure isotopic ratios of strontium and carbon in

sedimentary carbonates, which capture the evolving geochemistry of ancient seawater for regional and global correlation. Additionally, lithological correlation in the Precambrian is facilitated by the occurrence of well-dated glaciations that are unique in that they once covered the entire Earth.

After mapping, measuring stratigraphic sections, and sampling throughout southern Perú, I now have enough data to test previous tectonic models. Instead of originating from eastern North America, I think that the

Comparison of the tectonic history of the Arequipa terrane to potential sources in eastern North America and southwestern Africa



Arequipa terrane originated from southern Africa in a model consistent with the second thumb trick involving strike-slip motion. There is geological, geochronological, and metamorphic evidence for a suture in the Central Andes about 500 million years ago. I have documented collisional basin-forming events with volcanic arc-related detritus deposited from 540 million to 500 million years ago on the Arequipa terrane. During the same period, extensional rift-related sedimentation was instead occurring along eastern North America. Correlative basins, sources, and structures on the Arequipa terrane can be traced back through South America toward a source in southern Africa. Sedimentary provenance lends support with detrital signatures of 870 million- to 750 million-year-old rift magmatism that can be correlated with rift magmatism of the same age throughout southern Africa. In contrast, rift magmatism in eastern North America occurs later, from 760 million to 550 million years ago. Implications of my findings highlight a re-evaluation of the configuration of the supercontinent Rodinia, the importance of strike-slip

motion during terrane accretion, and potential feedbacks accreted basement blocks such as the Arequipa terrane may have on the evolution of active mountain belts. I still have a lot of work to do, but the Central Andes have proven to be a fertile area of geological research for years to come.

Central Andes terrane map



Field sites



Blake Hodgin (left) thanks his supervisor, Francis Macdonald, his committee, his field assistants, and his many collaborators, especially Victor Carlotto, Jim Crowley, and Mark Schmitz.

Earth Science Across Disciplines

Gen Ed courses broaden non-science concentrators' understanding



In this lab, students of SPU 12, *Natural Disasters*, investigate how low-velocity impacts influence the impact crater by dropping balls of different sizes from various heights into a basin of flour. The potential energy of the balls before they are dropped is used to determine the velocity of the impactor as it approaches the surface.

Although Harvard's Department of Earth and Planetary Sciences is known for being at the forefront of scientific discovery about the Earth and other planets, the department also annually welcomes 300 to 400 not-necessarily-science-oriented undergraduates for discoveries of another kind.

The students (freshmen through seniors) are enrolled in the department's Program in General Education courses. These courses feature a multidisciplinary approach to Earth and planetary sciences and scientific concepts including the social, political, economic, and ethical implications of humans' impact on Earth—and an understanding of the Earth's ongoing impact on us. (See the box at right for more information on Harvard's Gen Ed program and its objectives.)

BIG QUESTIONS

For many students, an EPS Gen Ed course may be their only Earth sciences course—ever. As such, EPS Gen Ed courses serve to deepen students' knowledge of the sciences as they simultaneously explore related social questions. Higgins Professor of Geochemistry Charlie Langmuir, who has been teaching Science of the Physical Universe (SPU) 14, **How to Build a Habitable Planet**, in the Gen Ed program since 2004 (and has authored a book with the same name), welcomes these students, especially those “afraid” of science. “In this course, I try to show them how interesting and exciting the science of the universe is,” says Langmuir, who is also director of Harvard's Mineralogical and Geological Museum.

Noting that most people have just a “vague awareness of the universal story of where we come from,” Langmuir contends

that this ignorance has “implications for how we live our lives.” Thus, in addition to developing an understanding of how we—and the planet—“got here,” Langmuir aims for his students to “appreciate the question of the significance of human life for planetary evolution,” and thus transform their perspectives of what it means to be an active inhabitant of the Earth.

“Whatever a student's field of concentration, achieving mastery of this material will provide a deep and empowering understanding of the planetary context for human life in the twenty-first century,” he writes in SPU 14's description, adding, “How could we live a meaningful life and make appropriate contributions to society and the world absent this understanding?”

Dan Schrag, Sturgis Hooper Professor of Geology and director of the Harvard University Center for the Environment, says that the discipline-breaking objectives of Gen Ed—in this case, to bring non-science knowledge together with scientific understandings—are key to the Gen Ed course he teaches, SPU 29, **The Climate-Energy Challenge**.

“Climate change is one of the great challenges of our time,” Schrag says. “And it seems to me that every Harvard graduate should come out of Harvard knowing something about it. Of the students in my class—some of them are going to be EPS concentrators, but—many of them are going to be lawyers, economists, politicians, business executives. Providing them with a quantitative understanding of the climate system and the energy system, and what needs to change to deal with climate change is part of our obligation as part of this institution, which has a very special role in training future leaders of our society.”

NOVEL APPROACHES

In conjunction with the Gen Ed program's mandate to reach beyond any one academic discipline and to reach across fields to address questions facing society, the program also encourages innovative teaching approaches, assignments, and final projects.

SPU 12, **Natural Disasters**, is one of the EPS Gen Ed course offerings with a wealth of experiential learning approaches. In the course, taught by Professor of Earth and Planetary Sciences Brendan Meade, students partake in demonstrations of volca-

A LITTLE BACKGROUND: GEN ED

Harvard launched its Program in General Education—eight courses students must complete in addition to their concentration requirements before graduation—in 2009, following a directive by former Harvard President Larry Summers in 2005. For the 30 years before that, undergraduate requirements had included what was known as the Core Curriculum.

This year, the Faculty of Arts and Sciences has been overhauling the eight-year-old program; a renewed Gen Ed program will be rolled out in fall 2018. Changes involve more clearly distinguishing the aims and content of courses taught in Gen Ed from the courses students take in departments, and refocusing the Gen Ed courses on topics and themes that students will encounter in life beyond the classroom.

Starting fall 2018, the program's eight required courses include four courses from each of the following groups: aesthetics and culture; histories, societies, individuals; science and technology in society; and ethics and civics. In addition, three distribution courses are required, one in each of the three divisions of FAS: arts and humanities; natural sciences and SEAS; and social sciences. Finally, the eighth requirement is one quantitative reasoning/empirical and mathematical reasoning course.

Stephanie Kenen, administrative director for the Program in General Education, explains that while Gen Ed courses focus on broad themes and important problems, the aim is not for students to “be solving problems, but rather to be considering how to understand complex problems and how to approach them from multiple perspectives.”

Kenen cites the inscriptions over Harvard Yard's Dexter Gate as a shorthand for the renewed Gen Ed program's mission. On the outside of the gate is the phrase “Enter to grow in wisdom” while the inside inscription rejoins with “Depart to serve better thy country and thy kind.”

“Students have four years here to learn about things that they will never have the opportunity to study again,” Kenen says in regards to the first inscription. As for the second inscription, she explains that while students are at Harvard, the goal of Gen Ed is for them “to apply what they're learning to their lives, rather than solving practical problems.”

Once they exit that gate, she says, “they have the rest of their lives to solve problems.”

noes spewing ping pong and whiffle balls, learn about the Coriolis force using a rotating see-saw, test the impact of precipitation and flooding on “landforms” they've created in a virtual sandbox, and witness resonance breaking a wine glass, among other experiences designed to help bring the science involved in natural disasters to life. On the real-life front itself, students use GIS software to map out areas that may be affected by different types of natural disasters (such as earthquakes, volcanoes, hurricanes, and floods), depending on the location of the ground movement and the ground material (rock versus sediment).

Langmuir's *How to Build a Habitable Planet* also involves demonstrations in nearly every lecture as well as physical experiences of the Doppler effect, meteorites, partial melting, and greenhouse warming in weekly labs. Similarly, EPS Department Chair John Shaw's Gen Ed course, SPU 31, **Energy Resources and the Environment**, features demos on wind turbines and solar cells, and students participate in experiential projects

to locate oil prospects and map oil spills.

Schrag, meanwhile, reversed the lecture format of *The Climate-Energy Challenge*: Before class, students watch “mini-documentaries” he created based on his lectures so that class time is devoted to discussion.

The course also includes a creative final project. In the first two-thirds of the semester, students learn about the climate system and climate change, and in the last third, they learn about energy systems that are at the core of the problem. “And then,” says Schrag, who is also co-director of the Science, Technology and Public Policy Program at Harvard Kennedy School,

SPU 25 students in one of the (very warm) steam tunnels running underneath campus from the Blackstone Steam Plant on Western Ave. The plant provides both electricity and heat to much of the Harvard campus. Bob Manning, Harvard's director of engineering and utilities, helped students understand how changes in the plant have improved efficiency and helped contribute to meeting Harvard's emissions reduction goals.

“they have to design a low-carbon energy system for the US—and write a term paper essentially justifying and explaining their choices.”

BROAD PERSPECTIVES

Gilbert Butler Professor of Environmental Studies Michael McElroy's Gen Ed course, SPU 25, **Energy and Climate: Vision for the Future**, has a similar, practical, multi-disciplinary component. Initially focused on energy security (then a major concern of the United States), the course now addresses energy and climate around the world, beginning (as does McElroy's 2010 book, *Energy: Perspectives, Problems, and Prospects*) with hunter-gatherers—providing a deep historical perspective to the big picture of how we arrived at the current situation regarding energy and climate. The material used in the present version of the course is taken from McElroy's more recent (2016) book, the title for which has been adopted as the title for the course.

This spring, McElroy's students were divided into six groups, each assigned a country or region (Brazil, China, the European Union, India, Russia, and the US) and tasked with devising “a plan to limit greenhouse gas emissions for the future.” The groups then met in a mock world climate summit—a “grand negotiation” to see how we can ... come up with a plan for doing this on a global basis,” McElroy explains.

“It's important for students in a course like this to actually learn from each other,” he says, noting that student papers have included a joint project on Harvard's plans to reduce its

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Faculty **CHRONICLES**

Francis Macdonald Named Full Professor

The department is delighted to announce Macdonald's promotion

Seven years ago, *Earth & Planetary Times* interviewed Francis Macdonald shortly after he joined the EPS faculty as an assistant professor, providing a brief snapshot of his academic background and his Harvard research. This spring, Macdonald, the John L. Loeb Associate Professor of the Natural Sciences since 2014, was promoted to full professor with tenure. Below is an update on his research, teaching, and other interests.

There's the thrill of collecting samples and data, analyzing the geology, and then testing hypotheses and theorizing about Earth history and climate; there's the pleasure of being outdoors in exotic and stunning locales such as Mongolia, Namibia, Spain, the Arctic, and Death Valley; and there's the fun of teaming up with Harvard colleagues—friends and experts in a variety of fields—as well as collaborating with top-notch scientists at other institutions. There is all that, but newly tenured Professor Francis Macdonald says the most rewarding aspect so far of his eight years on the EPS faculty has been advising students.

"I live vicariously through them," he explains, citing Blake Hodgkin's research in Perú (see cover story) as an example of a student taking him to places and academic questions he wouldn't normally have the time or background to explore. "I've learned a lot, and I've gotten to go to Perú and explore some of that geology, and it's been a blast," Macdonald says, adding that advising student projects also keeps him "a little bit outside of my comfort zone and ... pushes me to learn more," something he relishes.

"It's been really rewarding seeing these young people, who start as students, become friends, become colleagues, and then become successful, independent scientists," he says. The pleasure of these student-friend-colleague relationships is heightened, he suggests, owing to the abstract nature and time frames of his work—summarized in a research statement as seeking to reconstruct "the geological record of pivotal environmental transitions in Earth history, the tectonic evolution of continental rifts and orogenic belts, and the geological context of long-term climate change."

Basing his research that builds on the snowball Earth hypothesis that the Earth's surface was mostly or entirely frozen roughly 700 million to 600 million years ago, Macdonald, through fieldwork and geochemistry, strives to reconstruct the environmental changes on Earth during ensuing years to refine theories relating to the appearance of and evolution of animal life.

"The art is actually figuring out how to use the natural experiments, which are the geological record, to essentially test discrete hypotheses relating, for example, to different theories about why the Cambrian explosion occurred," he explains.

As the department's only field geologist, Macdonald strives to bring fieldwork into his teaching. "I really value the practical-experimental and so I try to do as much as possible," he says, referring back to his own academic trajectory from growing up in Idaho, to studying geology and planetary sciences at Caltech with advisor Joe Kirschvink, to spending two years in Australia on a Watson Fellowship to finish the meteor mapping work of Gene Shoemaker, to working with EPS Professor Paul Hoffman before joining the EPS faculty in 2009. (For more details, see the winter 2010 issue of *Earth & Planetary Times*.)

In the EPS 182, Stratigraphy and Sedimentology, field trip to Spain this past March, for example, Macdonald had the students pursue small, individual research projects: They collected data, analyzed it, and then wrote a paper integrating their findings with existing scientific literature. The paper was then reviewed by their peers following the academic peer-review process of the journal



Francis Macdonald

WINSTON MACDONALD

Geology, with Macdonald acting as the editor.

"The other thing I try to do in all my classes is that I try to make most of the projects they're doing to be completely collaborative, because that's the way the real world works," he says, noting that at Harvard he collaborates with EPS faculty such as Andy Knoll (and his students) on questions of paleontology and organismic and evolutionary biology; with David Johnston and Dan Schrag on geochemistry, making measurements in their labs; and with Robin Wordsworth and Eli Tziperman, applying their models of the ocean and atmosphere in extreme states to his observations relating to snowball Earth.

"Some of the big scientific advances right now are coming through, basically, the integration of different subfields and through linking—rather than specializing down and making more precise measurements. It's finding the connections between those measurements and fields," he says.

Tenure notwithstanding, Macdonald's teaching, advising, and research are likely to continue unabated. "At this point," he says, chuckling, "you've got these scientific questions you're obsessed with and it's hard to change track."

» *Cathy Armer*

John Holdren Returns to EPS

From “bookish boy” to Obama’s scientist, always bridging sciences and humanities

On a cold day in March 2017, two months removed from his job as one of the most visible scientists in the United States, John P. Holdren is camping out in a cramped office in the Kennedy School’s Belfer Center for Science and International Affairs. Having recently returned to Harvard from his position as assistant to the president for science and technology and director of the White House Office of Science and Technology Policy, Holdren reflects on his journey from self-described “bookish boy” to public scientist.

“I was a studious kid,” Holdren says. “I liked school and was generally at the top of my class.”

Holdren grew up fascinated by aircraft and rockets. As a boy in San Mateo, CA, he created homemade rockets from his mother’s empty lipstick tubes, and he learned to identify aircraft overhead by their silhouettes. By high school, he knew what he wanted to be: an aeronautical engineer.

And he might well have devoted his life to designing bigger versions of his childhood lipstick rockets but for the fact that his mother, a poet and fierce reader, always brought books home from the library for them to read. One day, she brought C.P. Snow’s *The Two Cultures* (originally published in 1959), which posited that Western intellectual life was split between the humanities and the physical sciences, and that the divide made solving the world’s most important problems needlessly hard.

Holdren was captivated by Snow’s thesis. “I realized that the most interesting problems in the world—energy, population, environment, food, international security—lived in the gulf between the social and physical sciences,” he says. “So, I decided I would work in that gap.”

Still, Holdren knew he had to master one discipline to be taken seriously as one who could speak to many. He chose plasma physics “because it was hard,” and because if he mastered that, no one could ever accuse him of not being able to “cut it” as a physicist, or of being a scientific dilettante as he pursued his passion for working “the gap.”

“Fortunately,” says Holdren, “plasma

physics turns out to be good training for working in environmental science, as well.”

Holdren earned his SB and MS from MIT in the mid-1960s, and his PhD from Stanford in aerospace engineering and theoretical plasma physics. (“I still use that background,” he says, “but it’s been a long time since I did any actual research in those fields.”) In 1988, at the age of 34, he became a full professor at the University of California, Berkeley.

But his career as a public scientist had already begun.

At Stanford, Holdren wrote a note to Professor Paul Ehrlich, author of 1968’s *The Population Bomb*. Ehrlich’s book warned about imminent mass starvation due to unfettered population growth, advocating wider access to birth control. Holdren—working the gap—advised Ehrlich to put more emphasis on the question of whether “technology will come to the rescue.”

Ehrlich was impressed, and sent Holdren in his place to a private meeting of the nation’s top experts on the interaction of population, resources, and environment. There, Holdren met Harrison Brown, who would become another mentor encouraging him to continue to address global issues.

Brown, a nuclear chemist and geochemist, had worked on the Manhattan Project. Like many of the scientists who helped build the bomb, Brown became a fierce opponent of nuclear weapons, and shortly after the bombs were dropped on Hiroshima and Nagasaki (the latter containing the plutonium Brown had helped figure out how to produce), he wrote *Must Destruction Be Our Destiny?* warning of the existential dangers of nuclear weapons and arguing for disarmament.

Holdren’s mentors, public scientists all, would multiply: George Kistiakowsky, another

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Former President Barack Obama and John Holdren in the Cabinet Room of the White House, March 2013.



HOLDREN

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Manhattan Project alumnus and science advisor to President Eisenhower; Jerome Wiesner, President Kennedy's science advisor, arms control advocate, and proud member of President Nixon's "enemies list"; and Roger Revelle, the oceanographer and Harvard professor who taught Al Gore, as an undergraduate, about climate change.

Is it any wonder that this bookish boy would become President Obama's chief scientist, co-chairing the President's Council of Advisors on Science and Technology, and recruiting Harvard University Center for the Environment Director Dan Schrag ("a brilliant geochemist but also drawn to public

service") to the then-president's committee?

Today, happy to be back at Harvard where his joint appointment to EPS and the Kennedy School allows him to "work the gap" on today's most critical issues, Holdren is asked about his biggest worry now that a president who "ran an evidence-based administration" has been succeeded by one who apparently doesn't plan to.

"Nuclear war," answers Holdren, perhaps recalling Brown, Kistiakowsky, and those other mentors who touched that future possibility. "Yes, I'm horrified by the setback that may come on efforts to address climate change, but we will be fortunate if that's the worst that happens."

» *David Rosenbaum*

John Holdren, age 11, in sixth grade at Beresford Park Elementary School, in San Mateo, CA, with an outstanding-achievement trophy, June 1955.

GEN ED

CONTINUED FROM PAGE 5

carbon footprint and a paper that looked specifically at South Africa's challenges. One of the papers submitted last year was recognized with the James Bryant Conant Prize for science writing.

Shaw's Gen Ed course, Energy Resources and the Environment, is similar to his course EPS 109, Earth Resources and the Environment, but is designed for the non-science concentrator, differing primarily in the intensity of the labs. "I find these courses are an excellent way to teach Earth science to students who might not otherwise explore these topics," Shaw says. In addition, "Energy and environmental topics are of such

great interest that [students] come to these courses highly motivated."

"Many of my Gen Ed students have gone on to fields that, while not strictly Earth science, are closely related to the topics we covered. It has been great to stay in touch with them, and [to] learn how aspects of a course can have a meaningful impact on their lives," says Shaw, who is also Harry C. Dudley Professor of Structural and Economic Geology in EPS and professor of environmental science and engineering in Harvard's John A. Paulson School of Engineering and Applied Sciences.

"While the varied backgrounds of the students pose challenges for teaching in Gen Ed, it also represents one of

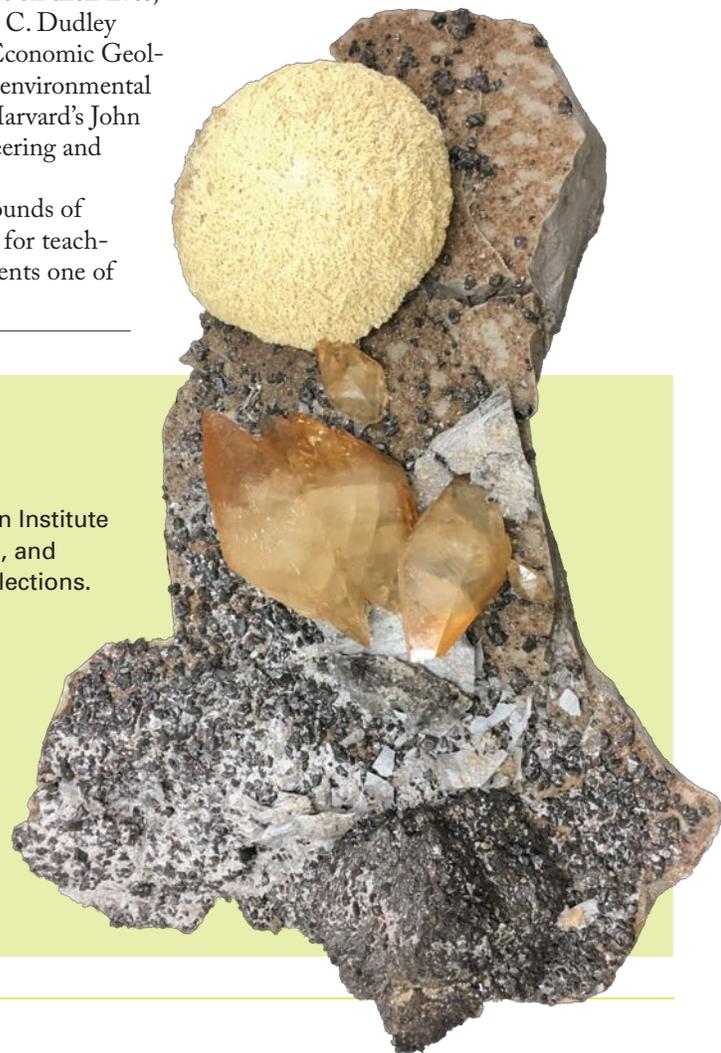
the most rewarding aspects of the courses," he says, noting that "solutions to pressing environmental issues generally require a mix of technology, policy, and public sentiment."

» *Cathy Armer*

MGM SHOWCASE

New cabinets and new donations are helping the Mineralogical and Geological Museum grow into its best self. The cabinets, funded by an Institute of Museum and Library Sciences (IMLS) grant, provide secure, stable, and easily accessed storage space for the museum's mineral research collections. They also provide space for new specimen donations, including this oversized piece measuring 29 by 19 by 8 inches and weighing 80 pounds. It features a "ball" of barite that is a complete sphere through and onto the other side of the slab and is accompanied by calcite crystals, sphalerite, and purple fluorite. It was acquired by Gary Fleck, who worked in the Elmwood mine in Carthage, TN. Such pieces were very common and extracted from this locality until 2004 when the mines were closed.

MGMH# 2017.4. Barite, calcite, and fluorite. Elmwood mine, Carthage, central Tennessee, Ba-F-Pb-Zn District, Smith Co. Donated by Kevin Schon, March 2017.



Alumni **PROFILES**

Judith Hubbard PhD '11 poses on a minibuggy—like the one she drove for her research in Nepal—in Oklahoma, where the trucks are made.



Sharing the Geology of the World Around the World

Judith Hubbard brings her excitement about Earth science to faults in Nepal, to a new undergraduate geology program in Singapore, and to children's science books for kids everywhere

For someone based at a university on the rainforest side of a small island in Southeast Asia (there is even a campus monkey) just a few years out from obtaining a PhD, Judith Hubbard's reach has been wide.

She teaches structural geology and GIS at the Asian School of Environment, part of Singapore's Nanyang Technical University (NTU), ranked among the top universities in the world; she takes students on field trips to Taiwan; and a documentary has been made about her work studying earthquakes in Nepal as an investigator at the Earth Observatory of Singapore. She also assisted with the launch of the undergraduate geology program—the first in Singapore and now in its third year—at the Asian School of Environment, and she has written five children's books about science topics. In

fact, she has just negotiated Korean translation rights for them.

Hubbard PhD '11 was raised in Ithaca, NY, with stints in France (her father, a math professor, taught there frequently during her childhood), and started academia as a math major at Caltech. The switch from math to geology resulted from a scheduling conflict. "I couldn't take number theory, so I reluctantly signed up for the geology class," she recounts.

And then Hubbard says the six words uttered by many in explaining their Earth-science-related

career paths: "We went on a field trip..."

She met her husband, Kyle Bradley, who also studied

CONTINUED ON PAGE 10



Judith Hubbard shows off her first three children's books.

geology, when both were freshmen. They came to Cambridge together in 2005: Bradley did his PhD at MIT while Hubbard was at Harvard. Now he is also a researcher at the Earth Observatory of Singapore and also an assistant professor at the Asian School of Environment. They had their son, Luke, now 6, while in grad school; daughter Evia is 2.

Hubbard's interest in earthquakes began at Caltech (as an aside, she has never felt an earthquake, even after four years in California) with a summer project mapping faults in Iran using satellite images for Caltech professor Kerry Sieh (now director at the Earth Observatory of Singapore). Sieh pointed Hubbard to Harvard's Department of Earth and Planetary Sciences, to Harry C. Dudley Professor of Structural and Economic Geology John Shaw (now department chair) for her PhD and interest in earthquakes.

At Harvard, Hubbard says, "I started a long-term plate tectonics project using data, but as I was working, there was an earthquake in my field area, the western Sichuan Basin in China. So I got to work on earthquakes after all, though only in terms of data."

In recent years, Hubbard's fieldwork has focused on rivers that cross the plate-boundary fault and are dry in the winter. She and her team use a special truck equipped with technology to visualize active faults in the subsurface of the Earth to discover how the faults have slipped in the past, and what that might mean for the future. (Her work along Nepal's Ratu River in 2014 was featured in an award-winning

"In eastern Nepal, we've learned a lot now about how deep the fault goes and how much it has slipped over time. ... But nobody has ever explored the subsurface in central or western Nepal."

~Judith Hubbard PhD '11

25-minute documentary made by NTU Professor Isaac Kerlow, available at <https://sites.google.com/site/judithahubbard/>.)

Hubbard has since considered similar projects in Bangladesh and Myanmar, but political and paperwork issues have given her pause, and she is now planning to return to Nepal.

"In eastern Nepal, we've learned a lot now about how deep the fault goes and how much it has slipped over time. And we're still working on integrating that data into publication. But nobody has ever explored the subsurface in central or western Nepal," she says.

Such research has important implications: In 1505, western Nepal experienced

an earthquake having an estimated magnitude of 8.5 or 9.0. "Scientists project that if a similar earthquake happened again in that region, it could kill up to half a million people," Hubbard says.

"The 2015 earthquake in Nepal was a little baby by comparison," she notes. (That earthquake, also known as the Gorkha earthquake, had a magnitude of 7.5–8.1, and was responsible for approximately 9,000 deaths.)

Hubbard enjoys teaching undergraduates in the geology program at the Asian School of the Environment (they remind her of Harvard students), but she is also reaching a much younger population—and continuing to learn more about science herself—as the writer of children's science books. Prompted by son Luke's curiosity, her own fatigue at reading the same books over and over to him, and the gap in children's science books in terms of presenting beyond-basic science for younger readers, she has written and self-published five books: *What Are Diamonds and How Do They Form?*, *What's So Cool about Mountains Anyway?*, *Plate Tectonics: The Engine Inside the Earth*, *Earthquake Science*, and *Earth's Changing Climate*. The books are available on Amazon as paperbacks and Kindle downloads.

"Earth science is something that's really approachable, but also neglected in US education," Hubbard says of her decision to take the content of her college lectures to a younger audience. "It's so exciting to learn about how the world works and how things are made inside the Earth and what the landforms on Earth mean."

» Cathy Armer

Speaking Many Languages

Firth McEachern's path combines Earth sciences, astronomy, languages, policy, and ... granola

"I'm an indecisive person," writes Firth McEachern '08-'09 in an email response to *Earth & Planetary Times'* queries for this alumni story.

What comes through in his answers to questions about where life has taken him since graduation, however, is not so much indecisiveness as a fun, fascinating, and nonlinear pursuit of multiple passions: Earth sciences, astronomy/astrophysics, languages and linguistics, education, and public policy, to name a few.

For the past two years, for example, McEachern has combined his interests in education, languages, and Earth sciences as

a consultant for SEAMEO INNOTECH, an intergovernment organization supporting education in Southeast Asia through research, training, and solutions development. He is responsible for projects on cyber safety and digital citizenship as well as on education following natural disasters.

"We've gathered data in the field about education challenges after calamities, and [we] are using that data to develop a guidebook for teachers to facilitate effective teaching and learning in emergency contexts," McEachern explains.

McEachern graduated from Harvard magna cum laude with a joint concentration in

Earth and planetary sciences and astronomy and astrophysics—though he also considered archaeology and languages and linguistics, given his ear for languages. (In addition to English, he speaks Arabic, Khmer, Ilokano, and Tagalog to various levels—the first two learned during his childhood, which, thanks to his father's work, featured stints in Jordan, Australia, Nepal, Cambodia, Egypt, and Scotland, along with three years in his native Canada.)

In the end, he landed in the right place at Harvard. "I loved the EPS Department," McEachern says. "I discovered many kindred spirits: down-to-earth, nature-loving, fun



Firth McEachern '08-'09 during a school visit in 2016 to conduct focus group discussions (FGDs) with school community stakeholders about alternative education in emergencies in the Philippines as part of his work with SEAMEO INNOTECH. The focus groups involved students, parents, teachers, and management.

people who like to challenge themselves physically and mentally. I grew up in an academic family that is fond of geography, traveling, camping, hiking, reading, and talking about science. Many of the people in EPS, both faculty and students, have similar interests. I felt at home there.”

EPS highlights include membership in the Harvard Geosociety (particularly the movie nights), serving as a teaching fellow for the introduction to geological sciences course (he won a Derek Bok teaching award), and EPS field trips. “These were times of bonding and waaay more learning than I expected,” McEachern writes.

Following a year in Cambridge working on a research project on the orbital dynamics



On the side, Firth McEachern and a friend recently launched the San Juan Fruit and Nut Company, a small operation that makes Sunrise Granola.

of asteroids with Professor Sarah Stewart-Mukhopadhyay (now at the University of California, Davis) and Matija Ćuk (then an EPS postdoc and now an investigator at the SETI Institute), in 2010 McEachern accepted a position in the Philippines with Sustainable Cities International, a Canadian nonprofit that works with local governments on issues of environment and sustainability.

It was at this point that his interest in languages reasserted itself. “In the hyperdiverse context of the Philippines, sustainability started taking on a broader meaning for me,” McEachern explains. “It’s not just the environment we need to manage responsibly, but also society, such as the vitality of cultures and languages that make the Philippines so special.” He notes that there are more than 170 languages spoken in the Philippines, 10 of which are spoken by 1 million people each.

As he began learning Ilokano and Tagalog, he wrote a weekly newspaper column about language, culture, and the environment. The column prompted concerned citizens to gather to brainstorm ways to protect their language (Ilokano) from decline. After some initial planning and lobbying by the group, the provincial government of La Union hired McEachern to coordinate the crafting and passage of a provincial law to safeguard and promote Ilokano; it passed two years later and was implemented over the ensuing

two years. In recognition of the effort, the government passed an ordinance declaring McEachern an “honorary Ilokano and son of La Union.”

During those years, McEachern appeared on TV engaging in an Ilokano word game with a Philippine TV celebrity, and he pursued a master’s degree in public management at Ateneo de Manila University, in Manila. He kept his education and EPS interests alive by teaching courses on multilingual education and on astronomy at a local college for future teachers.

In a completely unrelated direction, McEachern and Colleen Curran, a friend from his Sustainable Cities work, had been frustrated by the lack of healthy breakfast choices in the Philippines. In 2014 they began baking their own granola, and this year, with Filipino partners, they registered the San Juan Fruit and Nut Company, which produces Sunrise Granola using local ingredients. Although McEachern notes that it is “a very small-scale operation,” with baking just once per week, the company reflects McEachern and Curran’s philosophy regarding sustainability: The project provides livelihoods for women in the community, which had supported itself through fishing before the fish population began to decline.

McEachern isn’t sure where his interests will take him once his position at SEAMEO INNOTECH concludes this year. Another country? Another field? Another language? Another degree? You could say—as he might—that he is “indecisive.” But, given his enthusiasm and lengthy CV not 10 years out of Harvard, that doesn’t seem to be anything to worry about.

» Cathy Armer

“It’s not just the environment we need to manage responsibly, but also society, such as the vitality of cultures and languages that make the Philippines so special.”

~Firth McEachern '08-'09

Around *the* DEPARTMENT

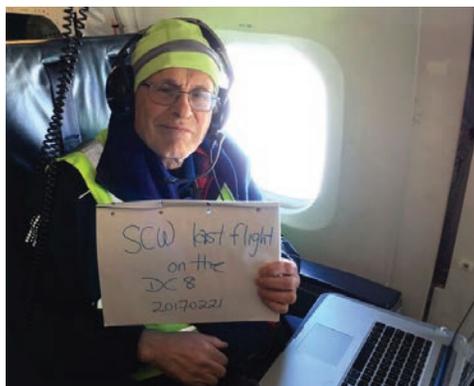
Faculty

James G. Anderson, Philip S. Weld Professor of Atmospheric Chemistry, has been awarded the 2016 Lichtenberg Medal from the Göttingen Academy of Sciences and Humanities. As stated in Göttingen Academy's communication, "The medal is given to outstanding scientists who have made their mark beyond their specific professional discipline and whose impact extends to the public at large."

Incoming assistant faculty member **Rebecca Fischer** has been named the Clare Boothe Luce Assistant Professor of Earth and Planetary Sciences for five years. The Henry Luce Foundation awards a small number of Clare Boothe Luce Professorships to institutions to forward Luce's wish "to encourage women to enter, study, graduate, and teach" in science, mathematics, and engineering.

The project of Frank B. Baird Jr. Professor of Science and Co-Head Tutor **Jerry X. Mitrovica**, "Sea Level Changes Following Antarctic Ice Sheet Collapse: Establishing a New State of the Art," received funding through the inaugural FAS Dean's Competitive Fund for Promising Scholarship. This project was selected from among nearly 60 proposals submitted by FAS faculty. Jerry also received the 2017 Everett Mendelsohn Excellence in Mentoring Award. (See photo at right.)

Harvard's Climate Change Solutions Fund, launched three years ago to encourage multidisciplinary research that seeks creative



▲ Abbott Lawrence Rotch Professor of Atmospheric and Environmental Science **Steve Wofsy**, principal investigator of the ATom Mission, on the ATom2, documenting his last time out on the Douglas DC-8 aircraft.



▲ Beneficiaries of Professor Jerry Mitrovica's excellent mentoring joined him at the GSAS award ceremony in April. Left to right: **Carling Hay**, postdoctoral fellow, **Tamara Pico G3**, **Kimee Moore G3**, **Sophie Coulson G1**, **Harriet Lau G5**, **Jerry Mitrovica**, and **Jocelyn Fuentes G4**.

solutions to climate change, awarded about \$1 million to seven research projects led by scientists, historians, economists, and public health experts from five Harvard Schools. Three EPS faculty were recipients:

Scot T. Martin for "An Early Warning System for Ecosystem Stress and Biodiversity Change in Equatorial Amazonia in Response to Climate Change"

Naomi Oreskes (along with Geoffrey Supran, Faculty of Arts and Sciences) for "Envisaging the Fossil Fuel-Free Future"

Daniel Schrag (along with Henry Lee, Harvard Kennedy School) for Identifying Challenges and Policy Pathways to "Deep Decarbonization" in China.

Naomi Oreskes, professor of the history of science and affiliate faculty member of EPS, received the Stephen Schneider Award for Outstanding Climate Science Communication during AGU's annual fall meeting in San Francisco. She was also awarded the 2016 Ambassador Award, which is in recognition for "outstanding contributions to one or more of the following area(s): societal impact, service to the Earth and space community, scientific leadership, and promotion of talent/career pool." In addition, Naomi

received the 2016 Frederick Anderson Climate Change Award from the Center for International Environmental Law, given in recognition of "Dr. Oreskes' work, which has been instrumental in highlighting the true weight and history of the scientific consensus behind climate change and the organized efforts by opponents of climate action to cast doubt on that consensus."

Robin Wordsworth, assistant professor of environmental science and engineering and affiliated faculty member of EPS, is one of four Harvard faculty who received the 2017 Star Family Challenge. In its fourth year, the Star Family Challenge provides seed funding to support FAS and SEAS faculty members in the natural and social sciences pursuing high-risk, high-impact projects with an interdisciplinary focus. At the April event Robin spoke on "Resolving the Status of Oxygen as a Biosignature to Allow a Search for Life on Exoplanets."

Academic & Administrative Staff

Zachary Adam, postdoctoral fellow in Andy Knoll's group and the Harvard Origins Initiative, received the 2017 Origins Project Postdoctoral Lectureship Award.

The \$10,000 award is offered to “promising young scholar-scientists on the basis of their scholarly achievement and potential, as well as their skills in science communication.” Part of the award is a weeklong residency at Arizona State University, where Zach offered a series of departmental colloquia and a large public lecture on the geochemical settings that could have allowed complex biopolymers to be produced in abundance on the early Earth.

Gina Armstrong, EPS’s financial associate, writes, “I went to Hawaii with the undergraduate students last August. It was quite an overall epic adventure. Travel, in the younger sort, is a part of education; in the elder, a part of experience.”

Rui Bao has joined EPS as a postdoctoral fellow in Ann Pearson’s group. Rui worked for three years at the Marine Geology Division of the China Geological Survey (CGS) in Guangzhou, China, after completing a BS at the China University of Geoscience in 2005. He earned a PhD at ETH Zurich in 2016, focusing on marine organic carbon cycling. He was a visiting student for half a year studying at the Woods Hole Oceanographic Institution (WHOI). Rui was awarded a Swiss National Science Foundation Postdoctoral Fellowship to work at Harvard to investigate factors affecting rates of carbon preservation and mineralization.

In April 2016, **Bishnu Bastakoti** joined the Juan Perez-Mercader group. Bishnu was born and raised in “the beautiful country of Nepal,” and he received a PhD degree from Saga University, Japan, under a MEXT (Japan’s Ministry of Education, Culture, Sports, Science and Technology) scholarship. He worked as a Japan Society for the Promotion of Science (JSPS) postdoctoral fellow at the National Institute for Materials Science, Japan. Before joining EPS, he lived in Australia and worked at the University of Sydney as a research associate. At EPS, he is working on how chemically induced patterns confer functional properties of a living system, and he is making simple non-biochemistry-based chemical systems that can grow and replicate as a result of physical and chemical processes.

Another new member of the Origins of Life Initiative working with Perez-Mercader is **Balanagulu Busupalli**. He earned a PhD in chemistry in May 2016, working on soluble layered materials with

B.L.V. Prasad at the Council of Scientific and Industrial Research (SIR)–National Chemical Laboratory, India. Bala joined Perez-Mercader’s group in June 2016.

Visiting postdoctoral researcher **Jörn Calties** came to EPS from the Department of Earth, Atmospheric and Planetary Sciences at MIT. Jörn is a physical oceanographer whose research aims at improving our understanding of ocean circulation and its role in climate. In particular, he is interested in the dynamics and impacts of submesoscale turbulence in the upper ocean, fronts and currents 1–10 km in horizontal extent that are thought to achieve important exchanges of heat, carbon, and other tracers between the surface and interior ocean. He also has a strong interest in the large-scale circulation of the deep ocean, which connects the vast deep-ocean reservoirs of heat and carbon with the atmosphere and thus plays a crucial role in setting the pace of past and future climate change. Jörn is working with Visiting Professor of Physical Oceanography and Climate Carl Wunsch throughout

the summer of 2017 before taking a faculty position at Caltech.

In addition to his promotion to assistant curator of the Harvard Mineralogical and Geological Museum, **Kevin Czaja** earned a master’s degree in environmental management and sustainability at Harvard’s Extension School. His thesis, “Arctic Meets Tropic: A Guide to the Calcareous Marine Mollusks of Massachusetts,” was awarded the Dean’s Prize for Outstanding ALM Thesis—Honorable Mention.

In September 2016, **Sudhina Guragain** arrived at the Earth and Planetary Sciences Department. She earned an MA in organic chemistry from Tribhuvan University, Nepal, and a PhD in colloidal chemistry from Saga University, Japan. Prior to joining Perez-Mercader’s group, Sudhina worked as a JSPS postdoctoral fellow at Kumamoto University and as a postdoctoral researcher at the National Institute for Materials Science, Japan. Sudhina is working on the fabrication of polymeric vesicles and utiliz-

TABLE TALK

In many ways, the fourth floor of Hoffman Labs is the hub of the department. With coffee available 24/7, cookies served daily at 3 pm, and pizza delivered at 5 pm on Fridays, the Student Lounge with its 11-foot-long oak table serves as a gathering spot for faculty, students, and staff throughout the day. The friendly and collaborative nature of the department often makes for interesting conversations, snippets of which are captured below.

“I’m terrified that there are millions and millions of people like my family out there.”

“... so how much magnesium do you need to run the analysis?”

“It’s easier to understand if I just skip to the end.”

“I only use purple and green to mark papers; red ink stresses students.”

“I don’t like Tang.”

“Which is why you could never be an astronaut.”

“He’s a good guy but he really doesn’t understand science.”

“Potato chips are a problem for people with diabetes because of the carbohydrates.”

“Yes, but potato chips are so good that if you don’t eat them you die of a broken heart.”

“If he can come down, there’s a lot of information between 150 and 300 meters.”

“Nitrogen/oxygen, nitrogen/oxygen—it’s scientists churning themselves into butter.”

ing them as nanoreactors for oscillating chemical reaction for the investigation of the origin of life.

Jordan Hemingway joins EPS from the MIT/WHOI Joint Program in Oceanography, where he recently earned a PhD in marine chemistry and geochemistry. Jordan's background is in understanding the role of erosion and riverine processes in the global carbon cycle. He uses biomarkers and isotopes to track different carbon sources and sinks during transit to the ocean. He is at EPS as a postdoctoral fellow working with Ann Pearson and David Johnston.



Esther James

▲ EPS Preceptor **Esther James** completed a PhD in geophysics with a focus in seismology (mantle tomography) from Boston University in May 2016. Her dissertation was titled "Three-Dimensional Shear Wave Velocity Structure in the Atlantic Upper Mantle."

In September 2016, **Pat Lau** joined the Perez-Mercader group working as a part-time administrative assistant. She earned a BS in biochemistry and a BA in Asian studies from the University of Massachusetts, Boston. Before joining EPS, Pat worked at a pharmaceutical retailer for a few years.

Chenyu Lin earned a BS in medicinal and applied chemistry from Kaohsiung Medical University and an MA in analytical chemistry from National Kaohsiung Normal University, Taiwan. Chenyu received a PhD

in the field of supramolecular chemistry at Clarkson University, NY, where he primarily investigated self-assembled pi-pi interactions and their applications. He also investigated material science at Xerox Corporation as a visiting scientist. He joined Perez-Mercader's group in February 2017, where he is working on polymerization-induced self-assembly (PISA), vesicles, and their applications.

In June 2016, **Andrew Muscente** joined the Knoll group as a postdoctoral researcher. Before coming to Harvard, he received a BS in biological sciences from Cornell University and a PhD in geosciences from Virginia Tech. Drew, a paleontologist and geobiologist, focuses on fossils of complex eukaryotes in the late Neoproterozoic-early Paleozoic interval (~1000-450 Ma) of the geologic record. By studying the paleobiology and paleoenvironments of these fossils, Drew aims to understand the rise of animal life and its impact on the Earth system.

Department assistant **Summer Smith** joined EPS in June 2016 with an extensive background in retail management and customer service, including 10-plus years of experience. As an EPS department assistant, Summer is involved with general department administration, including organizing meetings and events. She sits in the Hoffman fourth-floor main office with Maryorie Grande.

Rohit Srivastava comes to EPS after receiving an MPhil in chemistry from Dr. Bhim Rao Ambedkar University, Agra, India, in 2010. After graduating, he worked as a project fellow on a University Grants Commission (UGC) major research project at Motilal Nehru National Institute of Technology (MNNIT), Allahabad, India. Rohit earned a PhD from Birla Institute of Technology, Mesra, Ranchi, India, in 2015, after which he worked as a postdoctoral fellow at the Department of Inorganic and Physical Chemistry, Indian Institute of Science (IISc), Bangalore, India. Currently, he is a postdoctoral fellow in Perez-Mercader's group at the Rowland Institute, where he is involved in the project "Top-Down Synthesis of an Ex-Novo Chemical Artificial Living System."

Chris van Houtte joined EPS in September 2016 as a postdoctoral researcher studying big earthquakes in Marine Denolle's group. He received his PhD from the University of Auckland and worked at GNS Science (the New Zealand geological survey) for two years before coming to Harvard.

Also joining Denolle's group is **Loic Viens**. Loic received an MS from the Institut de Physique du Globe (IPGP), France, in June 2013 and a PhD from the University of Tokyo, Japan, in September 2016. He came to EPS in October 2016 as a postdoc and is currently working on earthquake ground-motion simulations and on monitoring the changes in the Earth's near-surface caused by megathrust earthquakes.

Graduate Students

Thirteen graduate students began their first year in the department in fall 2016. We extend a hearty welcome to:

Timothy Clements, Cornell University
Sophie Coulson, University of Liverpool
Minmin Fu, University of California, Davis
Ana Gonzalez Valdes, Columbia College
Yajui Ku, National Taiwan University
James Muller, Pomona College
Judy Pu, MIT
Tia Scarpelli, Michigan Technological University
Aleyda Trevino, MIT
Franklin Wolfe, Washington and Lee University
Xiaoting Yang, Peking University
Zhuo Yang, University of Science and Technology of China
Jiuxun Yin, University of Science and Technology of China

Two EPS graduate students won the Outstanding Student Paper Award at the AGU 2016 fall meeting: **Eugenia Hyung** G6 for "142Nd/144Nd Heterogeneity in the Proterozoic to Phanerozoic Mantle and Implications for Mantle Mixing"; and **Lauren Kuntz** G4 for "The Pacific Ventilated Thermocline and Its Impact on Global Temperatures."

Harriet Lau G5 received the AGU Graduate Research Award for the SEDI (Studies of Earth's Deep Interior) Focus Group. She was recognized for her work developing and applying a new method for estimating deep Earth structure: tidal tomography.



▲ **Chris Horvat** PhD '17, an applied mathematician and polar oceanographer who works with Professor **Eli Tziperman**, is one of five people participating in *Enduring Ice*, a documentary about sea ice decline. This summer, the small team—recently named “Expedition of the Year” by the Royal Canadian Geographical Society—will traverse Nares Strait in three kayaks to study how ice floes break up under the action of ocean waves. The data the team collects will be used to improve climate models and to spotlight the essential role of Arctic sea ice in the planet’s ocean and future. Above, in red kayaks, members of the *Enduring Ice* team navigate Nares Strait.

Teachers Extraordinaire

The winners of the 2015–16 Shaler Teaching Award are **Yanpeng Sun** G4, a teaching fellow for EPS 171, Structural Geology and Tectonics, in fall 2015, and **Will Steinhardt** G6, a TF for ES 123, Introduction to Fluid Mechanics, in spring 2016. The Shaler Teaching Award is given annually to teach-



▲ **Tamara Pico** G3 and **Emma Bertran** G4 make liquid nitrogen ice cream as a part of the end-of-year party last May.

ing fellows who exhibit excellence in teaching. Each recipient of this award receives an “Outstanding EPS Teaching Fellow” certificate, an engraved Estwing rock hammer, and \$500. Congratulations—and thank you—to Yanpeng and Will.

In addition, four EPS graduate students, one EPS fellow, and one EPS postdoctoral fellow received the spring 2016 Harvard University Certificate of Distinction in Teaching. The Bok Center for Teaching and Learning reserves this award for outstanding teaching fellows. All scored 4.5 or higher (out of a total of 5) on their teaching evaluations.

Jacky Austermann G5, EPS 261, Sea Level Change

Emma Bertran G3, EPS-OEB 56, Geobiology and the History of Life

Mary Moore G7, SPU 12, Natural Disasters

Will Steinhardt G5, ES 123, Introduction to Fluid Mechanics

Sarah Dendy EPS Fellow, SPU 12, Natural Disasters

Jenan Kharbush, EPS Postdoctoral Fellow, EPS 22, The Fluid Earth: Oceans, Atmosphere and Environment

Undergraduate Students

Matt Luongo '17, an EPS-ESE joint concentrator, writes: “After graduation ... I’ll be working as an energy and utilities consultant at West Monroe Partners in New York City. I’ll be working on renewable tech and grid modernization primarily. This coming summer before starting the job, I’ll be making a cross-country road trip with a college friend to visit friends scattered throughout the US and visit new sites and national parks. After that, who knows!”

EPS-ESE joint concentrator **Mattie Newman** '17 will start a three-month summer internship with Chevron after graduation, working in Chevron’s Health, Environment and Safety team as an environment and climate change intern. “I will be helping with environmental stewardship tasks as well as potentially working on Chevron’s climate change United Nations policies. I will be located in Houston, TX, and during the internship hope to apply to graduate school or look into other work.”

In SITU & In SILICO

1. **Marena Lin G4** sits on a century-old living root bridge constructed by the matrilineal Khasi tribe in the rainiest place on Earth, near Cherrapunji, Meghalaya, India. Marena, working with Professor of Earth and Planetary Sciences and Environmental Science and Engineering **Peter Huybers**, studies precipitation variability in the South Asian monsoon, and to understand her data, she spent the summer of 2016 seeing “what it is like on the ground” while also meeting and visiting colleagues in India and understanding precipitation-collection methods throughout India’s history.



2. Abbott Lawrence Rotch Professor of Atmospheric and Environmental Science **Steve Wofsy**, research engineer **Bruce Daube**, and postdoctoral fellow **Róisín Commane** flew around the world twice this year on the NASA DC-8 as part of the NASA Atmospheric Tomography Mission (ATom). The ATom mission aims to quantify the effects of humans on the chemistry of the most remote parts of the atmosphere.



3. Boots air drying after a power wash following the EPS 109, Earth Resources and the Environment, field trip to energy sites in Pennsylvania and Massachusetts. Stops included a natural gas drill rig near Montrose, PA, coal mines near Scranton, PA, and photovoltaic and hydro plants in Holyoke, MA.



4. Professor **Francis Macdonald** (left) describes a fossil coral to **Scott Wieman G2** near Miravete de la Sierra, Spain, during a field trip this past March. Two classes—EPS 182, Stratigraphy and Sedimentology, taught by Francis, and EPS 189, Analytical and Field Methods in Geobiology, co-taught by **Ann Pearson** and **Dave Johnston**—joined forces to travel to northwest Spain. This trip provided participants with an outcrop-scale example of how sequence stratigraphic analysis may be used to describe carbonate-dominated successions. The students also gained experience measuring sections and collecting samples.

5



5. Last August, 21 students drove north to New Hampshire and Maine for the annual graduate student field trip. They set up camp in Barnes Field Campground, Baxter State Park, Acadia National Park, and Bradbury Mountain State Park. The geology portion of the trip focused on the geologic record of sea level and glaciations in New England, igneous rock and pegmatite formation, closing of the Iapetus Ocean, the intrusion of the Sebago Pluton, Mesozoic Magmatism, and Pleistocene glaciations and sea level. The itinerary also included studying Maine's terrestrial and marine ecology. This group shot was taken atop Cadillac Mountain in Acadia National Park.

6



6. **Matt Miller '18** participated in last summer's Juneau Icefield Research Program (JIRP). For over 60 years, JIRP has offered a field-based curriculum in the Coast Mountains of Alaska and British Columbia, with students learning a wide range of disciplines, including glaciology, geology, climatology, and biology. Matt notes, "JIRP was perhaps the best experience of my life. The depth and breadth of the science curriculum were beyond anything I could have expected, and the mountaineering and wilderness education we received was beyond compare. The opportunity to develop my field skills in a beautiful place with wonderful friends brought my love of Earth sciences and learning more generally to new heights."

7



7. **Tamara Pico G3**, **Natalya Gomez PhD '14** (now an assistant professor at McGill University), **Evelyn Powell G2**, and **Holly Han**, a graduate student in Natalya's research group, take in the view during last September's PALSEA Conference in Mount Hood, OR.

8



8. **Matthew Moody '19**, shown here lava poking, was one of the 19 undergraduates who went to the Big Island of Hawaii for the annual field trip, this year led by **Lou Derry PhD '90** and **Alex Moore PhD '93**. The itinerary included studying geomorphology and fresh water systems, coral reef ecosystems, endangered forest ecosystems, and volcanic processes and active volcanism.

Alumni NOTES

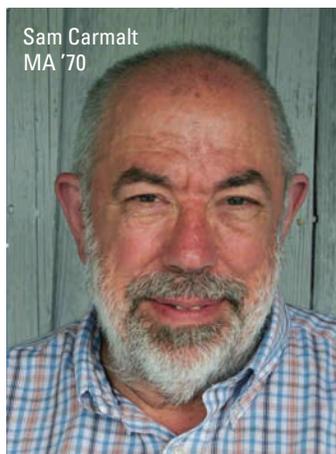
Graduate Students

Donald D. Runnells MA '60, PhD '64, drunnells2@msn.com: After leaving Harvard I worked for four years in geochemical research with Shell Development Company in Houston, TX, and Coral Gables, FL. I then taught for two years at the University of California, Santa Barbara, followed by 24 years at the University of Colorado, Boulder. In 1993 I retired from the University of Colorado as chair of the Department of Geological Sciences. I then began a second career as president of a small environmental consulting firm in Fort Collins, CO. I continue to do a small amount of private consulting work, but I am largely retired. I am married with two grown children and five grandchildren. Now, at 80 years of age, I am learning to play the piano.

My Harvard student office and many of my classes were located in the Vanserg building. The building had a military history that dated from World War II (maybe even World War I). During my tenure at Har-

vard, the ROTC occupied the bottom floor of the building. Of my graduate colleagues, certainly the best known is Harrison (Jack) Schmitt, who was the first geologist to set foot on the moon. There are still a few of our other graduate colleagues hammering on rocks, but many others have gone on their last great field trip!

Sam Carmalt MA '70, scarmalt@swconsult.ch: Since leaving Cambridge in 1974, I've both practiced geology and done a variety of other interesting things such as designing databases and working for humanitarian organizations. I'm neither rich nor famous, but I've had lots of fun doing it all. Now I've



Sam Carmalt
MA '70

LEONARD STOKES

circled back and am a full-time PhD student at the University of Geneva (Switzerland), again in geology, and writing a thesis to (finally, I hope) add the letters P, h, and D after my name.

Throughout, I've known that I'm an academic at heart. The thesis explores the limits, both geologic and economic, of the Marcellus formation natural gas resource. Tangentially, Springer has just published my book *The Economics of Oil*. The bottom line of that is that there is plenty of reduced carbon available in the lithosphere to use for energy. But there are limits, both economic (the easy, cheap stuff is gone) and societal (primarily climate change), to question whether the present global economy can survive if it continues to be fueled by fossil sunshine.

Despite my poor French, I've survived in Geneva for 35 years now, and have managed to acquire Swiss citizenship. It's home. So be sure to let me know if you're in town, as I'm always ready for an end-of-day beer.

Philip Goodell PhD '70 ('71), philipgoodell43@gmail.com: I have initiated the Center of Entrepreneurial Geosciences (CEGS), <https://science.utep.edu/CEGS/>, at the University of Texas, El Paso. Check it out. We are doing amazing things: courses,

field trips, special lectures, and master's theses (soon a certificate).

I work full time at the university, and recently produced my 33rd and 34th PhD students. I currently have three PhD and two MS students between two departments. One MS student has staked a claim in my research area. Overall, my research spans regional geochemical mapping for probing the soil environment, heavy rare earth elements (HREE) resources on rift shoulders, cratonic blocks in Mexico, and other topics. I'm also intrigued by semimetal boiling in epithermal systems.

My passion today is directed toward entrepreneurial geosciences and CEGS. The motto/objective of CEGS is "to make resource discovery more efficient." Also: "You do not have to be an employee all your life." I'll be leading a one-day short course of the same name in Lima, Peru, in May, in Spanish (with help from the crew). We will then take it to the PDAC conference in Toronto next March. The center is looking for scholarship funds, and seeks to build participation for one-year (certificate) and two-year (potential MS) educational activities.

I remain a longtime friend with a giant in JBT-type chemical thermodynamics today named Richard Sack, Harvard PhD '79. He won an award at the American Geophysical Union meeting two years ago (igneous branch) and last year was the invited speaker at the Russian Academy of Sciences, Institute of Geology of Ore Deposits, Petrography, Mineralogy and Geochemistry's Memorial Readings in Honor of D.S. Korzhinski.

I am grateful that Texas has no mandatory retirement age for us. Our president, Dr. Diana Natalicio, turns 78 this year and is going strong.

K.C. Lee AM '72, kcoldman@yahoo.com: I earned a master's in geophysics in 1972, and went on to become an oncologist. Now retired, I find myself somehow rediscovering physics—fundamental quantum mechanics. At the moment I'm reacting to a lecture by Professor Sidney Coleman (http://media.physics.harvard.edu/video/index.php?id=SidneyColeman_QMIYF.flv) across Oxford Street, given circa 1991, and seeing possible connections with Frank Wilczek, from down Mass Ave., regarding physics in 100 years (see <http://www.pbs.org/wgbh/>

IN MEMORIAM

Stuart M. Smith AM '60, a specialist in submarine geology at Scripps Institution of Oceanography at the University of California, San Diego, died on September 4, 2016, at the Encinitas Nursing and Rehabilitation Center.

Douglas Whiting Rankin PhD '61, a distinguished scientist with the US Geological Survey and specialist in northern and southern Appalachian geology, died of respiratory failure February 25, 2015, in Washington, DC.

Richard W. "Dick" Birnie PhD '75 passed away on September 21, 2016, at Hospice House in Concord, NH. He had joined Dartmouth's Department of Earth Sciences in the 1970s where he taught for 34 years and conducted research in mineralogy and crystallography, volcanology, and remote sensing.

Steve Bushnell PhD '83 passed away at the Huntington Hospital in Pasadena, CA, on November 1, 2016.



David Nolan '90

▲ **David Nolan '90**, PhD '96, dnolan@miami.edu: I earned my BA in physics in 1990 and my PhD on vortex dynamics with Brian Farrell in 1996, and I have been at the University of Miami for 15 years, currently serving as chair of the Department of Atmospheric Sciences. This year's research highlight was being a mission scientist in NOAA's SHOUT (Sensing Hazards with Operational Unmanned Technology) program, working with the NASA Global Hawk aircraft in September 2016. I worked overnight shifts monitoring the track of the aircraft as it flew over and around Tropical Storm Karl in the Atlantic. My job was to update the flight path to account for storm motion and to avoid overshooting cloud tops.

[nova/next/physics/in-100-years/](#)). Anyone who happens to be interested, do get in touch.

Floyd McCoy PhD '74, fmccoy@hawaii.edu: For the academic year 2016–2017, I am on sabbatical leave in Greece, at the American School of Classical Studies at Athens, at the new Malcolm H. Wiener Laboratory of Geoarchaeological Science. This time is a reprieve from the University of Hawaii, where I teach in the geosciences at two campuses—a needed break to finish research projects and attempt to publish that data. And travel ... it is not easy to focus on professional stuff here in Athens with all the history and culture, and the invitations to lecture elsewhere in the country and in Europe ... not to mention Greek food and hospitality. The research is really a continuation of my doctoral thesis under Ray Siever in 1974, which has persisted with focus on the marine geology of the eastern Mediterranean—blending the geosciences and the archaeological sciences into the new field of geoarchaeology.

► In the complete blackness of night in the open ocean of the central Pacific, **Hilary Close** PhD '12 prepares underwater instruments for deployment on the deck of the R/V *Kilo Moana*. On this cruise she served as chief scientist.

Marguerite "Mimi" Gerstell AM '91 (geophysics), mimigerstell@yahoo.com: After my master's, I finished my PhD in the Planetary Science section at Caltech.

Recently I've been having fun running around to a bunch of state colleges in Florida to peddle my book, *Fish Stories by a Scientific Nobody*. It's an attempt at comedy and/or sociology but also presents the content of my/our research. Prominent characters include Yuk Yung and Richard Goody;

brief appearances by Fred Abernathy, Oded Aharonson, Joann Stock, Allan Robinson, Bruce Murray, Dudley Hershbach, Bill Klemperer, Darrell Strobel, John Tate, and Ed Moise. Price is three pi dollars on Amazon.

In April I gave my "Mars" talk at Stetson U, rated number 5 among Southern "regional universities." Hmm. Also spoke at Haverford/Bryn Mawr colleges, equal to Harvard among undergraduate schools. Of the half-dozen colleges where I spoke, the best book buyers were at Eastern Florida State ... of course! They're Space Nuts with internships at Cape Canaveral.

Jeffrey J. Love PhD '93, jeffreylove137@gmail.com and jlove@usgs.gov: I am presently working in the Geomagnetism Program of the US Geological Survey. My homepage is <https://www.usgs.gov/staff-profiles/jeffrey-j-love>.

Richard Holme PhD '95, R.T.Holme@liverpool.ac.uk: I am currently professor of geomagnetism at the University of Liverpool, UK.

Bernhard Steinberger PhD '96, bstein@gfz-potsdam.de: I am still at GFZ German Research Centre for Geosciences, in Potsdam, Germany, as reported in the 2015 *Earth & Planetary Times*.

Hilary Close PhD '12, hclose@post.harvard.edu: I recently started a tenure-track faculty position in the Department of Ocean Sciences at University of Miami's Rosenstiel School of Marine and Atmospheric Science in Miami, FL. In between my postdoc at University of Hawaii and my position in Miami, I worked for a year and a half in a



Hilary Close PhD '12

BLAIRE UMHA/UNIVERSITY OF SOUTH CAROLINA

joint position with the US Geological Survey and University of California, Santa Cruz. I continue to collaborate with my colleagues from Hawaii, Santa Cruz, and the USGS. I am busy building my lab in Miami, bringing on students and staff, creating and teaching a new course in marine organic geochemistry, continuing my seagoing fieldwork, and worrying about hurricanes. You can get a taste of my research on YouTube: <https://youtu.be/uA3VU9FCWxI>.

Helen Amos PhD '14, helen.amos@gmail.com: I'm currently an American Association for the Advancement of Science (AAAS) Science & Technology Policy Fellow hosted by the US Environmental Protection Agency in the Office of Research & Development working on innovations to protect the environment and human health. Previously, I worked with Reed Harris Environmental Ltd. and at Harvard University in the Biogeochemistry of Global Contaminants and Atmospheric Chemistry Modeling groups.

Undergraduate Students

Lincoln Hollister '60 ('61), linc@princeton.edu: My retirement (2011) from teaching metamorphic petrology at Princeton University did not squelch my passion for unraveling the history of rocks by studying the minerals they contain. For example, I am now involved with a team trying to understand how quasicrystals and other Cu-Al-Fe intermetallic minerals formed that are a part of a meteorite that fell in eastern

Russia more than 6,000 years ago. The team even named one of the new minerals after me (hollisterite- Al_3Fe).

I am still basking in the glow from the tributes I received at last fall's annual meeting of the Geological Society of America. One tribute was a four-day field trip into an area in northern New Mexico where several former students and colleagues and I had worked. Then, at the meeting, there was a full day of oral papers and a poster session on research inspired by some of the things I had done over the past 50 years. One speaker managed to put my name and that of Korzhinski in the same sentence! (JBT students will understand this connection.)

I am currently co-conspiring with a couple of former students to hold a GSA-sponsored Thompson Field Forum in northern British Columbia in mid-August 2018. The proposal hasn't yet been submitted, but it is based on the inspiration of Jim Thompson's bequest to GSA in support of Field Forums for the purpose of bringing important geologic terranes to the attention of the next generations of petrologists.

Raymond V. Ingersoll '69, rvingersoll@gmail.com: I will evolve into *emeritus* status this June, following 35 years at UCLA. Enjoying life, both professionally and personally.

Paul Milde '82, paul@sculling.com: Here is a picture of me in the nice flannel shirt. I'm standing on a glacial erratic just down Church Street from my house in otherwise flat and swampy Mattapoisett, MA. Every summer I spend time in some photogenic Precambrian banded gneiss on Georgian Bay in Canada, but I keep forgetting to either bring the flannel or take a picture when I am there.

I really enjoyed the Geology Department. It was a small friendly place and I got to know the other concentrators, graduate students, and professors in a way that I think is unusual in other departments. I particularly remember Professors Thompson, O'Connell, Petersen, and Burnham, and I wish I had



Paul Milde '82

spent more time outside of class with them. When I was graduated in 1982 there were not many jobs. Something like 120 hand-typed letters yielded one offer as a temporary employee with the Energy Minerals division of the USGS. I spent 18 months there, helping to map potential uranium deposits in southeast Utah. That was great, but another 200 letters did not help me find a job in industry, and, since I did not want to teach, graduate school didn't seem like a good bet either. Instead I worked in manufacturing for a while, got a business degree at MIT, had some more jobs managing manufacturing, then in 1997 bought a very small company making composite rowing shells—and I am still building boats.

The chemistry and heat transfer equations I learned are a little bit helpful in understanding our processes, more useful than anything I learned in business school. My old hand lens is handy for inspecting flaws in the finish, and the Brunton compass makes a great paperweight. I do miss geology, but at least when I travel I try to do a little research into the local geology, and I still find the rocks more interesting than the birds and plants.

Gillian Salton '90, ggsermd@gmail.com: If anyone is interested or remembers the late '80s, I am well but no longer a geologist of any sort. After finishing my master's in geology while on a Fulbright in New



Sally Fagerson McGill '85

SALLY MCGILL

▲ **Sally Fagerson McGill** '85, smcgill@csusb.edu: I have been teaching geology at California State University, San Bernardino, for 25 years and am now department chair. I continue to conduct neotectonic/paleoseismic research on active faults in southern California along with undergraduate and master's students. I have fond memories of my time as a geology major at Harvard.

NEXT STEPS: 2015–16 SENIORS

When we checked in with the 19 concentrators and secondary fielders who graduated last year to see what their next-step plans were, we were not surprised to hear the wide range of answers:

Tyler Barringer: “I’m working for The Economist Intelligence Unit Canback, a consulting firm that focuses on businesses located in emerging markets.”

Taylor Benninger: “I am currently working for the US Attorney’s Office in the District of Massachusetts, getting very excited about a future legal career and impressing my colleagues with my knowledge of geophysics. (Thanks, Jerry!)”

Alyssa Chan: “I work at the Harvard Law School Food Law and Policy Clinic, which works to identify policy solutions that increase access to healthy foods, assist small and sustainable farmers, and reduce food waste. As program coordinator, I contribute to and help manage the Farm Bill Law Enterprise, focusing on increased access to land and credit for socially disadvantaged and beginning farmers, and I also work on the food waste initiative.”

Patrick Dowling: “I am working as a product manager at PowerScout, an early-stage startup in the Bay Area focused on making smart, sustainable home improvement projects simple.”

James Duncan: “I finished a three-month tour through South America where I was building a photography portfolio, speaking Spanish, building roofs, and doing a little geo-recon for Blake Hodgins. I am currently in Wanaka, New Zealand, where I am continuing work on my photography (see jamesduncanphotography.com), playing rugby, and preparing a vineyard for harvest.”

Hanna Evensen: “I was a paralegal in environmental litigation at Weitz & Luxenberg in New York City and then in December I moved to Vienna, Austria, where I am pursuing stand-up comedy. I plan to return to the States in the fall for law school and continue with the stand-up side.”

Carolyn Gigot: “I received a Michael C. Rockefeller Memorial Fellowship, which is a postgraduate, yearlong experience intended to provide immersion in a foreign culture. I am traveling in the northern Indian Himalaya; after the summer and fall studying Hindi and bicycle touring, I am now working and learning thangka painting at the Thangde Gatsal studio near Dharamsala.”

Sam Goldberg: “I am now a PhD student at MIT, studying geomorphology with EPS alum Taylor Perron.”

Wilson Kuhnel: Wilson is an investment banking analyst at Morgan Stanley in New York City.

Joseph Lanzillo: “I’m currently spending a year in Tanzania where I’m getting involved with various energy projects to learn about the changing energy landscape in East Africa, as well as playing tons of soccer!”

Rodrigo Leal: “I am currently working at the City of Austin’s Office of Sustainability, a small department in the municipal government tasked with research, coordination, and implementation of sustainability programs and initiatives.”

Katja Lierhaus: “I am an associate footwear engineer for the running category at Nike. Currently, I am working on the Flyease, a shoe designed specifically for easy entry/exit and targeted to a population with limited dexterity such as those with CP. This project is particularly rewarding because creative solutions are needed to accommodate those who desire independence but don’t have the mobility to tie their own shoes.”

Ellen Robo: “After working as a data analyst for Hillary for America, I am figuring out what I am doing next. Hopefully, it will include more Earth science than campaigns do.” (See the photo of Ellen’s quilt featuring an EPS T-shirt on page 25.)

Cecilia Sanders: “I’m currently in my third term as a PhD student in geological and planetary sciences at Caltech. I’m carrying forward some of the work I did for my senior thesis in EPS, thinking about past Mars climate and its habitability potential, as well as the preservation potential of biosignatures from early Earth and Mars. I’m still entertaining dreams of being a geologist astronaut.” (See photo on page 25.)

Dan Skarzynski: “I’m working for Alan Rooney down at Yale’s department of geology and geophysics doing research similar to what I did for my thesis; that is, Re-Os chemostratigraphy work.”

Hank Smith: Hank is a man of mystery.

Jack Stobierski: “I moved to New York in July and started working at a real estate firm called Raith Capital in their acquisition department. In my free time I enjoy examining the schist outcrops in Central Park.”

Erik Tamre: “Having completed my national service, I am working on Estonia’s education system for the rest of my compulsory year off from academia: I am reforming a private school’s natural science curriculum and advising a company working on a virtual learning environment that helps high school students learn math and physics.”

Austin Wu: “I’m working as a data scientist and web developer for OppSites, where I’m helping urban communities identify and promote economic development opportunities. Then my weekends are full of climbing and skiing in the Sierra Nevada Mountains!”

Zealand, I started a PhD in geophysics at the University of Colorado and then dropped out, bummed around a few years, and then went to medical school. I am now a physician in Bend, OR. It's a better fit overall, though I certainly miss the intensely creative aspect of academics. Joan Fryxell, who was a postdoc in the late '80s, is still a good friend and was up visiting me in Oregon this spring. She has been a well-respected full professor at Cal State San Bernardino for many years now. Best to the department!



Dan Goldner '91

Dan Goldner '91, goldner@post.harvard.edu: After seven great years of teaching high school in Dorchester, I've returned to simulation and data analysis, with some fun projects including writing models to interpret mental health data. Always looking for other interesting things to learn about!

Leslie Hsu '00, lhsu@usgs.gov: In September 2015, my family moved to the Denver area so that I could start a job as the coordinator for the USGS Community for Data Integration. I'd love to meet other alumni in the USGS. We're living in Golden, CO, so close to the Rockies, and I can't wait for my 1-year-old daughter to get a little older so we can go hiking together and look at rocks.

It's fun seeing fellow EPS alumni at various geoscience meetings. As vice chair for the Geoinformatics Division at the Geological Society of America, I must remind you to join in, be active, and volunteer in your relevant communities and societies (and check out the GSA Geoinformatics Division)!

Hugh Daigle '04, hugh.daigle@gmail.com: After graduation, I spent the summer of 2004 as an intern at S.S. Papadopoulos and Associates in Bethesda, MD, and in October of that year I moved to Midland, TX, to

start work as a wireline field engineer for Schlumberger. Working on oil rigs in west Texas was a bit of a culture shock, but the experience changed the course of my career. After three years working as a field engineer and later as a petrophysicist, I enrolled at Rice University and graduated with my PhD in Earth science in 2011. The topic of my dissertation was microstructural controls on fluid flow and methane hydrate distribution in fine-grained marine sediments. After briefly working for Chevron in Houston, in 2013 I started my current position as an assistant professor in the Department of Petroleum and Geosystems Engineering at the University of Texas at Austin. My research focuses on accumulation of methane hydrates in marine sediments, production of gas from hydrate reservoirs, laboratory and theoretical analyses of fluid flow in shales, and applications of nanotechnology in oil and gas exploration and production. It's a little hard for me to believe that I have lived in Texas for 12 years now. In 2009 I married Elizabeth Peterson (Harvard Class of 2005) and we have two sons: Oliver (age 4) and Rory (age 2).

Caitlin Siobhan Bergin '06, csbergin@gmail.com: I spent five glorious years in Alaska after graduation, then accepted a transfer to Calgary, Alberta, in 2011. I met my wife the first week I moved to Canada, and now, married to a Canadian, I am north of the border to stay. For the past three-plus years I've been a senior environmental advisor at Chevron working on the Pacific Trail Pipelines and Kitimat LNG Projects. In May 2018 I'll finish my MS in environmental science and engineering at Johns Hopkins University. Landlocked in cowboy country, I frequently wear cowboy hats and have been spotted posing with mini-donkeys at the Calgary Stampede.

Frances Moore '06, fmoore@ucdavis.edu: I started as an assistant professor in the Envi-

ronmental Science and Policy Department at UC Davis in July 2016 after finishing my PhD in environment and resources at Stanford in 2015. I am working on quantifying the social and economic impacts of climate change and our ability to adapt to them.

Danielle Lehle '07, lehle.danielle@gmail.com: It's hard to believe it's been 10 years (yikes!) since I graduated, but I'm looking forward to coming back for reunion. I am currently serving as a Presidential Management Fellow with the National Park Service. I work as a natural resource specialist at the NPS office in Lakewood, CO, and my division works with parks all over the country to help them with planning projects, whether it's visitor use management, trails management, wilderness stewardship, strategic planning, or resource stewardship. Hopefully, when my fellowship ends in 2018 the NPS will decide to keep me around longer. When not working, I play percussion with the Lakewood Symphony



Caitlin Siobhan Bergin '06

Orchestra and try to spend as much time in the mountains as possible.

After graduation I bounced between working as a park ranger (Wyoming, summer) and as a geological technician (Utah, winter) for several years before applying

to a few graduate programs and finally enrolling at the Yale School of Forestry & Environmental Studies. I graduated with a Master of Environmental Management, specialization in ecosystem conservation and management, in May 2015. I'm thrilled to be back with the park service and working with people who are passionate about conservation. In the meantime, if you happen to be passing through Denver, please give me a shout—my skis or hiking boots are always prepared for a day in the mountains!

Adam Sachs '07, adam.e.sachs@gmail.com: I recently published my first book of fiction, *Inherited Disorders*, which consists of 117 stories about fathers and sons. Story #51, about a dispute between a meteorologist father and son over whether the air at the core of extratropical cyclones is “very cold” or only “moderately cold,” should indicate, I hope, that I didn't completely squander four years of an EPS education. (Please don't tell me if I got the science wrong.)

Alec Engell '08, sunengell@gmail.com: I have a year or two left in a doctoral program in solar physics at Montana State University, where the Physics Department specializes in that field. I married my wife, Kez, in 2016. Currently on a break from my PhD, I work at NextGen Federal Systems under NASA and other contracts studying and developing prediction models for solar eruptions to mitigate against their negative effects on humans and technical infrastructure (missions to Mars, satellites, electrical grids, etc.).

Allen Pope '08, allen.pope@post.harvard.edu: I rang in 2017 in (practically the middle of nowhere) Iceland. I've moved to the North Atlantic for the next few years where I will be running an organization called the International Arctic Science Committee. At IASC I'll be helping Arctic scientists work across national and disciplinary boundaries, representing Arctic science, and facilitating science-policy interactions with the Arctic Council. Come visit me in Akureyri sometime!

Tidings

EPS is always pleased to hear from our alumni and friends. Send us your comments or news to epsnl@fas.harvard.edu. So that we may print your notes and photographs, please include with your submission:

- 1) your affiliation and year; and
- 2) the following statement:

I give consent for display of the note, my email address and/or web-link and any associated photo, which may or may not appear in print and electronic versions.

Daniel Stolper '08, dstolper@berkeley.edu: After finishing my postdoc at the end of 2016 in the Department of Geosciences at Princeton (working in part with Harvard alum John Higgins '02, PhD '09), I began this past January as an assistant professor in the Department of Earth and Planetary Science at the University of California, Berkeley.

NEXT STEPS: 2015–16 PHD GRADUATES

Seven EPS graduate students received their doctorate in academic year 2015–2016. With dissertations electronically bound (available online at <http://dash.harvard.edu/>) and PhD diplomas in hand, our most recent alumni have dispersed around the globe.

Jacqueline Austermann

Dissertation: “Imprints of Geodynamic Processes on the Paleoclimate Record”

Advisor: Jerry Mitrovica

Current position: Newton International Fellow, Department of Earth Sciences at the University of Cambridge

In 2018: Faculty at Columbia University

Kristian Bergen

Dissertation: “Pleistocene to Modern Deformation of the Central Los Angeles Basin”

Advisor: John Shaw

Current position: Management Consultant, McKinsey & Company, Stockholm

Uyanga Bold

Dissertation: “Neoproterozoic to Paleozoic Geology of Southwestern Mongolia”

Advisor: Francis Macdonald

Current position: Postdoctoral Fellow, University of Tokyo, as a Japan Society for the Promotion of Science Fellow

Mary Moore

Dissertation: “Stable Water Isotopes as Tracers in Global Precipitation”

Advisor: Zhiming Kuang

Current position: Impact Manager, City Year San Jose/Silicon Valley, CA

Alex Robel

Dissertation: “Ice Stream Variability and Links to Climate”

Advisor: Eli Tziperman

Current position: NOAA CGC and Stanback Postdoctoral Fellow, California Institute of Technology and University of Chicago

Emily Smith

Dissertation: “Constraints on Global Carbon Cycling, Basin Formation, and Early Animal Evolution during the Neoproterozoic and Early Cambrian”

Advisor: Francis Macdonald

Current position: Postdoctoral Fellow, Smithsonian Museum of Natural History

In 2017: Johns Hopkins University

Joseph Stockmeyer

Dissertation: “Active Deformation over Multiple Earthquake Cycles in the Southern Junggar Fold-and-Thrust Belt, NW China and Fractured Reservoir Characterization Using 3D Geomechanical Restorations”

Advisor: John Shaw

Current Position: Geoscientist–Exploration, Chevron Corporation, Houston, TX

Alexa Weingarden '08, alexa.weingarden@post.harvard.edu: In January, my husband, Matt Granoff (Harvard Class of 2007), and I welcomed our daughter, Verity! I'll finish my MD at the University of Minnesota in May (having completed my PhD in microbiology there in 2015), and then move to Palo Alto for an internal medicine residency and a gastroenterology fellowship at Stanford University. I plan to continue my research on the human gut microbiome during the fellowship—it's a field I became interested in after doing research in environmental microbiology as an undergraduate in the EPS Department.

Benjamin Miller '10, renequademiller@gmail.com: I recently began working for the Massachusetts Executive Office of Energy and Environmental Affairs on the Global Warming Solutions Act team—very exciting work.



Yelun Qin '10, Lu Wang, and their daughter, Elizabeth Kara Qin.

Yelun Qin '10, yelunqin@gmail.com: My wife, Lu Wang, and I began the new year welcoming our baby girl, Elizabeth Kara Qin, on January 2. It's been a wonderful and tiring new change to our life. I've since put up a poster of dinosaurs next to the changing station, and I can't wait to teach my daughter about rocks, fossils, and Earth history!

I continue to work as a spiritual advisor with InterVarsity Christian Fellowship at Northeastern University (Boston), and have in the past couple years become an affiliate staff at Northeastern's Center for Spirituality, Dialogue, and Service. I get to meet and advise all sorts of high-caliber students who care about the environment, social justice, service, and the role that faith and spirituality can play in invigorating these endeavors. And of course when the students ask me about my college experience, I fondly tell them about my time in the EPS Department—

sharing everything from the lab work, to field trips, the awesome people, and of course the afternoon cookies and Friday night pizzas. Lu Wang is a preceptor in Harvard's Department of Chemistry and Chemical Biology, teaching Physical Sciences 10 and 11.

Isaac Shivvers '11, isshivvers@gmail.com: I'm graduating with my PhD in astronomy from Berkeley this spring. After that, I'll be applying for jobs in the Berkeley/San Francisco Bay Area. I'm always happy to hear from old friends, so if you're ever in town, just get in touch and say hello!

Ross Anderson '12, ross.anderson@yale.edu: After nine years in the United States (four at Harvard and five at Yale), I'll be heading back across the pond in October after being elected to the fellowship at All Souls College, Oxford. There I will continue to work on fossil evidence for the evolution of complex life. I look forward to welcoming many of my American friends to visit England!

Kristi J. Bradford '12, kristi.j.bradford@gmail.com: I've been working at an asteroid mining startup for nearly two years. I decided to leave academia to pursue not just a job in industry, but a job that may lead to the creation of an entirely new industry. I started with Planetary Resources as an instrument systems engineer, helping to build the remote sensing payloads that will fly onboard the com-

pany's test spacecraft slated to launch later this year. But more recently my days have been filled with planning an interplanetary space mission to prospect near Earth asteroids for hydrated minerals. I'm currently the company's acting director of instrument systems and thus I manage the selection and development of our prospecting payload suite. I have one of the coolest jobs I could ever imagine. Although it was difficult to leave academia

and scientific research behind, I know that if Planetary Resources is successful, my efforts could revolutionize planetary science, by making space exploration more economical, more accessible, and thus more common.

Sarah MacVicar '13, sarah.macvicar@gmail.com: I finished up an MSc in health geography at McGill last year, and I am now in medical school in the University of British Columbia's Northern Medical Program. I was surprised and delighted to discover a couple other medical students who were geologists in their past lives, so it's been nice to have other folks around to "talk rocks."

Libby Felts '14, esfelts@gmail.com: I completed my MSc in petroleum geoscience at Imperial College London in September 2016, with the graduation ceremony this May. After an internship with ExxonMobil at their Leatherhead (UK) office last summer, which doubled as my master's thesis, I was offered a full-time position with the company based out of the Houston office. After relocating on January 2, I started as a geoscientist working Colombia Operations in the ExxonMobil Exploration Company. I am loving the work so far, learning a lot, and enjoying reconnecting with Harvard friends both at work and through the Harvard Club of Houston.

Valerie Shen '14, i.am.valerieshen@gmail.com: I started 2016 still as a management consultant with McKinsey & Company. The best part was exploring southern Africa through a project in Johannesburg. In June, I began a new job in venture capital, with Kleiner Perkins Caufield & Byers' Green Growth Fund, investing in teams applying emerging technologies to traditional industries.

In fall 2017, I will be starting my MBA at Stanford's Graduate School of Business.

Rodrigo Leal '16, joseroodrigo.leal@gmail.com: During my time as an undergrad in the EPS Department, I constantly found myself connecting what I learned in my Earth and environmental science courses to the topics I studied in my geography, urban studies, and



Kristi Bradford '12

PLANETARY RESOURCES INC.



▲ **Ellen Robo '16** sends this photo of a quilt she recently made. "It includes the T-shirt from the Hawaii field trip so I wanted to share it. I didn't dare cut up my flannel and EPS denim shirt but maybe next time I am making a quilt like this they will be too worn to wear and can be added." (For Ellen's update, see "Next Steps: Seniors" on page 21.)

anthropology courses. I knew that while I was extremely interested in climate science and meteorology, I was even more passionate about understanding the relationships between environmental, built, and social systems.

Shortly after graduation last May, I packed my bags and headed back to my native land of Texas to explore the intersection of sustainability, resilience, and urban planning (and to escape the cold Cambridge winters!). I was fortunate enough to find a promising work opportunity in Austin, TX, a dynamic and fast-growing city known as a hub for all things "green." I am currently working at the City of Austin's Office of Sustainability, a small department in the municipal government tasked with research, coordination, and implementation of sustainability programs and initiatives. Right now, I'm working closely with a cross-departmental team of planners, engineers, and other city experts to develop Austin's first-ever Climate Resilience Plan, which will aim to make Austin resilient to climate-related shocks and stresses through adaptation and preparedness measures. I'm also collaborating with our food policy team to gather data on food insecurity within the community that will help inform future investments targeting improved access to healthy and affordable food for all Austinites.

While the path toward addressing these wicked problems may sometimes seem

unclear and difficult, it is extremely rewarding to know I am contributing to a dedicated team that is working to advance social equity, combat the impacts of climate change, and move the city toward a more sustainable urban future.

Cecilia Sanders '16 (joint EPS–astrophysics), csandersstop@gmail.com: I'm currently in my third term as a PhD student in Geo-



Cecilia Sanders '16 at Badwater Basin, in Death Valley, CA.

logical and Planetary Sciences at Caltech. I'm carrying forward some of the work I did for my senior thesis in EPS, thinking about past Mars climate and its habitability potential, as well as the preservation potential of biosignatures from early Earth and Mars. My research is going great—I think about the production of organic molecules on icy moons until I get stuck, and then I go think about growing microbes on Mars analog rocks! And there are tons of opportunities for fieldwork, especially in Death Valley. I even went back and found the geocache from Francis Macdonald's January field camp on top of Noonday Peak!

In addition to my studies, I teach science to kindergartners, first-graders, and second-graders at a local public elementary school every Wednesday—focusing on sustainable energy, ecosystems, basic physics, electricity, and magnetism. I've also been involved in some campus political activism, art, and public outreach events ... AND I wear my EPS flannels and chambray pretty much every day! All in all, SoCal life is treating this East-Coaster well.

I'm looking ahead to doing some Mars analog fieldwork this summer in either Angola, Western Australia, New Zealand, or Turks and Caicos (depending on how research goes this term)!

ALSO I'm still entertaining dreams of being a geologist astronaut, and every time I go to the gym, go on a hike, or crack open a book ... that dream sustains me. And I have Harvard EPS to thank for keeping that dream alive during some critically formative years.

I Remember **WHEN**

A Short Account of St. Barbara's Day Celebrations

BY ROBERT KAMILLI PHD '76

There is considerable uncertainty about the origin of the St. Barbara's Day celebration at Harvard. According to Jim Hays, former professor and department chair of EPS, the celebration of St. Barbara's Day was an established tradition when he arrived as a graduate student in 1961 and was celebrated annually by EPS students on December 4 with much merriment, singing, and drinking (especially drinking).

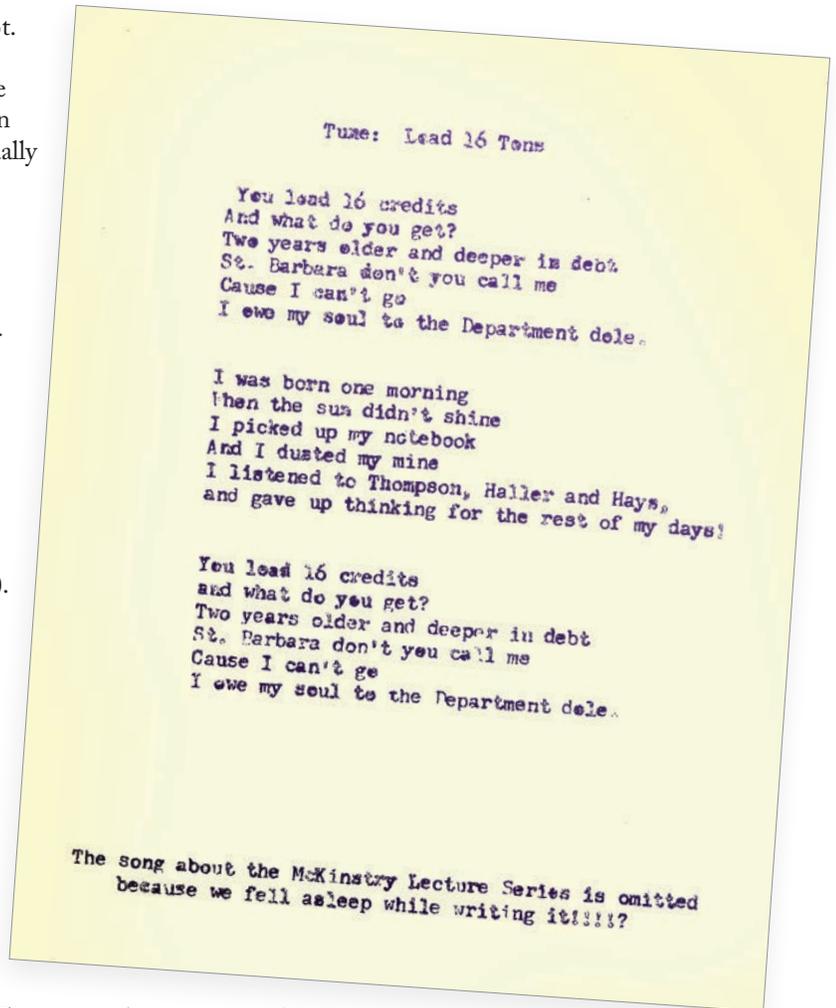
During this author's time at Harvard (1969–76) St. Barbara's Day was celebrated in one of the storage rooms in the basement of the Geology Museum, perhaps because it reminded one of a stope in an underground mine and probably because it was easier to clean up the mess afterward. The celebration started off staid enough, with Professor Cornelius Hurlbut (who taught mineralogy and petrography at Harvard from 1931 to 1972, when he became an emeritus professor) reciting from memory several poems by Robert W. Service, the "Bard of the Yukon," including "The Shooting of Dan McGrew," "The Ballad of the Ice-Worm Cocktail," "The Cremation of Sam McGee," and "The Three Bares" (this last poem referring to a family's three-hole outhouse).

After a decent pause, when students could refresh their drinks and many faculty could unobtrusively take their leave because they knew from experience what was to come, mimeographed songbooks were handed out and wonderful songs were sung lustily, most of which gently (or not so gently) made fun of the faculty. Typical titles included the likes of "16 Credits," "Clifford's (Frondel) Crystal," "Jingle (James F.) Hays," "Gimme That Ole Time Geology," "Charlie (Burnham) on the Glide Plane," "The Twelve Days of Classes," "Oh, Kummel (Bernhard), Ye Faithful," "The Ballad of Bernie (Kummel) and Ray (Siever)," and "Hey, Mister Ternary Man." Pauses were taken between each song so the celebrants could freshen their drinks.

At the department's annual spring banquet, which was held in May, one of the numerous, dubious prizes awarded was The [Name Withheld] Memorial Waste Basket, originally named for a graduate student who was found at the end of the St. Barbara's Day celebrations with arms encircling said basket. In following years, The [Name Withheld] Memorial Waste Basket was awarded to the person who made the biggest fool of him- or herself during the previous St. Barbara's Day celebrations, with the recipient's name being duly inscribed on the side of the container in Magic Marker.



Reproductions of a songbook cover and lyrics sheet from Bob Kamilli's era of celebrating St. Barbara's Day at Harvard.



At some time after this author left Harvard in 1976, this "traditional" manner of celebrating St. Barbara's Day was discontinued, probably in the interest of good taste and certainly in the interest of safety.

» Bob Kamilli thanks former Professor Jim Hays PhD '66 and Sam Carmalt MA '70 for their contributions to this account.

St. Barbara lived in the third century AD. According to legend, while her father was away, she became a Christian. Upon his return, he was horrified that she had converted. Despite savage tortures, St. Barbara would not deny Christ. Finally, her father took her to the country and beheaded her. Returning from this dreadful deed he was overtaken by a storm and struck dead by lightning. Consequently, the name of St. Barbara came to be invoked as a protection against lightning, and hence explosives. She became the patron saint of gunsmiths and armorers, and through gunpowder, of miners, although many non-mining geologists also celebrate her. She is particularly revered by miners in Central and Eastern Europe and in Latin America.

Top *It* All OFF

Originally swag for EPS graduate students, these caps are now available for our alumni and friends. If you would like to proudly proclaim your connection to the department by acquiring an EPS baseball cap, please complete and mail the order form below, including a check for \$15 (per cap) made payable to Harvard University.

Questions? Please send an email to epsnl@fas.harvard.edu.

For our full collection of photos of people donning EPS-embellished clothing, visit our website: <http://eps.harvard.edu/campus-and-beyond>.

EPS concentrator Mattie Newman '17 wearing her cap while lava poking in Hawaii during last August's undergraduate field trip.



EPS Baseball Cap Order Form

Relaxed twill, adjustable strap in back makes it a one-size-fits-all hat.

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STUMP THE SCHOLAR CONFOUNDING LAYERS

Submitted by the Wofsy-Munger Group on Biosphere-Atmosphere Exchange

The puzzle: Why did we see very high concentrations of sulfur dioxide in several layers in the most remote locations of the Arctic this past February?

Submit your answer to epsnl@fas.harvard.edu. The winner will be selected by the time-tested method of placing all correct answers in a hat and with closed eyes the editor will draw one name. The winner will receive an EPS baseball cap and the honor of having his or her name listed in the next issue of *Earth & Planetary Times*—along with the correct answer, of course.

LAST ISSUE'S ANSWER: GRAVITAS

The puzzle: Those of you with long memories may recall that in our last issue, then-undergraduate student Sam Goldberg '16 presented the challenge to identify where the highest gravitational acceleration from Earth's mass is found and explain why.

The answer: If the Earth were a sphere of uniform density, then the gravitational acceleration would increase linearly from the center of the Earth to the Earth's surface, and then decrease with the square of the radius as one moved upwards from the surface into outer space. However, the Earth is not a uniform sphere (as the chart on the right shows)! The core is significantly denser than the mantle and the crust. Thus, the highest acceleration is found at the core-mantle boundary and is about 10 percent greater than the acceleration at the surface.

The outcome? The scholar, Robert Berman '49, receives an honorable mention for his admirable but not correct submission.

Giving to EPS

EPS undergraduate and graduate programs have grown substantially in recent years, in part reflecting society's growing interest in energy and climate but also reinforced by our efforts to maintain strong foundational programs in geology, geophysics, geochemistry, and atmospheric and oceanographic sciences. Our goal is to continue to enhance these educational programs and expand our research in ways that will lead to exciting discoveries that benefit society.

If you are able and interested in making a financial contribution to EPS, please send a check made payable to Harvard University, with a note indicating that it is for the Department of Earth and Planetary Sciences, to: *Department of Earth and Planetary Sciences, Hoffman Labs, Attn: Kathleen McCloskey, Harvard University, 20 Oxford Street, Cambridge, MA 02138.*

