Understanding the History of Atmospheric Oxygen

Proxies required at all scales

BY EMMA BERTRAN, FIFTH-YEAR GRADUATE STUDENT

Oxygen is essential to macroscopic life today. We take it in with every breath, knowing there is plenty of it to do so. But if this were Earth millions of years ago, would there have been this much oxygen available to breathe? Probably not, but how can we know for sure?

Understanding the history of atmospheric oxygen is a mystery that keeps biogeochemists awake late at night, and up early in the morning; it is arguably the most important environmental change in Earth history. To unlock the details of the story of oxygen on Earth, one must think at all scales possible, from the atomic to the global.

Appreciable oxygen first appears 2.45 billion years ago owing to the evolution of oxygenic photosynthesis, marking the initiation of the Great Oxidation Event (GOE) (Figure 1, page 3). The period that followed, dubbed the “boring billion,” was a time of remarkable chemical stability in the atmosphere and the ocean, and of modest evolutionary activity. The Earth saw the second rise of atmospheric oxygen roughly 550 million years ago, a period marked by extreme climatic events (major glaciations) and the Cambrian explosion, which gave rise to large animals that in turn required high atmospheric oxygen levels to survive. Sometime thereafter, oxygen abundance balanced to the modern levels we enjoy today.

Having this cartoonish record is all well and good, but you might ask how it was built. Oxygen is a highly reactive element, which renders its transcription into the rock record, the keeper of Earth history, challenging.

The history of atmospheric oxygen is told thus via proxies. These so-called proxies indirectly record atmospheric oxygen: tracking changes in these related processes, whose history is more

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Welcome to our latest issue of Earth & Planetary Times! This New England spring finds us celebrating another rewarding academic year, congratulating an accomplished group of graduating students, welcoming new faculty, and digging out from late-season nor’easters. We welcome Kaighin McColl, a new assistant professor in climate science and hydrology who is jointly appointed with the Environmental Science and Engineering (ESE) program in the School of Engineering and Applied Sciences. Two other faculty with ESE appointments—Frank Keutsch (also in the Department of Chemistry) and Elsie Sunderland (also in the School of Public Health) have become affiliates of EPS, and we continue to expand and revitalize our spaces and laboratories to accommodate other recent faculty appointments and promotions. Our new junior faculty have helped us to strengthen our curricular programs, particularly by offering courses in our new “50-level” course series—a set of courses that are a step beyond a traditional introductory class, providing an in-depth foundation to the various disciplines represented in EPS.

Harvard is in a time of major leadership transition, with Larry Bacow being named as the next University president. We also anticipate transitions in the dean of the Faculty Arts and Sciences and the dean of science positions, the latter position having been filled for the past decade by our colleague Jeremy Bloxham. The EPS community is very grateful for Jeremy’s insightful leadership and support of EPS, and we look forward to welcoming him back into the fold.

Issues we face as a broader society have also motivated efforts within our community. Over the past few months, we have held a series of department-wide functions on sexual harassment and gender-based discrimination, discussed concerns regarding international travel bans, and advocated in Cambridge and Washington for the value of scientific inquiry in addressing many of our most pressing societal concerns. In all of these efforts, we have deeply appreciated the motivation, insights, and energy provided by our graduate students and researchers, who have helped lead the charge!

I hope that you enjoy reading about these and many other happenings in Earth & Planetary Times.

Best regards,

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

FROM THE CHAIR

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CONTINUED FROM COVER

Atmospheric Oxygen easily translated to the rock record, allows changes in atmospheric oxygen to be inferred.

The sulfur cycle, and sulfur isotopes in particular, is one of the proxies that provide a window into past oxygen levels. My research focuses on this cycle’s main players, and the chemical signatures they produce and leave behind.

The largest reservoir of sulfur on Earth is seawater sulfate (Figure 2). It enters the ocean through rivers, via continental crust weathering, which itself depends on atmospheric oxygen levels. Sulfur exits the ocean by forming sulfate minerals (barite or gypsum), or via reduction to sulfide, forming pyrite (fool’s gold). Pyrite burial indirectly affects oxygen levels: pyrite burial leaves oxygen behind. The balance between these input and output fluxes establishes the amount of dissolved sulfate in seawater. To track changes in this balance, biogeochemists follow variations in the sulfur isotopic composition (the ratio of $^{34}$S to $^{32}$S, expressed here as a δ$^{34}$S value in units of per thousand, or per mil) of sulfate and sulfide, which, as they are buried in sediments, effectively preserve the history of these changes. We then infer these changes to be tracking changes in atmospheric oxygen budgets.

On a global scale, the sulfur cycle encompasses many processes. Placing constraints on the behavior of the sulfur cycle is thus essential, and at the center of this cycling are bacteria inhabiting mud at the bottom of the oceans.

Sulfate reducing bacteria (SRB) are the main drivers of sulfur biogeochemical cycling in marine sediments (Figure 2, red arrow). These microorganisms perform dissimilatory sulfate reduction (DSR): instead of breathing oxygen and producing carbon dioxide, they breathe sulfate and produce hydrogen sulfide. The latter then combines with iron, and forms pyrite. SRB only thrive in the absence of oxygen, and as such are found living deep in marine sediments, where dissolved oxygen is low.

SRB are only one part of a larger microbial community within marine sediments, each with its specialized metabolism. These include sulfur disproportionating bacteria (SDB), which live through fermentation: they utilize sulfur substrates such as sulfite ($SO_3^{2-}$) or thiosulfate ($S_2O_3^{2-}$), and produce both sulfate and sulfide (Figure 2, blue arrows). This is not a great way to make a living, as it yields little energy, but it has served them well over time.

Microbial sulfur metabolisms produce specific isotopic signatures, evident in the sulfur isotopic composition of sulfate and sulfide. These isotope signatures reflect the metabolism, physiology, and environmental conditions present. Biogeochemists then work hard at calibrating these signatures in the lab to unravel preserved environmental information hosted in the rock record.

Sulfur disproportionation was thought to have a significant role in sedimentary sulfur cycling, particularly during the second rise of atmospheric oxygen. However, evidence has shown that disproportionation is not a major player in marine sediments. Like a fly on the wall, it is there, but doesn’t contribute much to global budgets. That said, this lack of involvement doesn’t mean these microorganisms are not effectively recording very specific environmental changes. SDB require very narrow environmental conditions to thrive: a little bit of oxygen (but not too much) and iron (plenty of it). Changes in these conditions are recorded in the SDB signature, but not necessarily in the DSR signature. This link needs proper calibration, and for this, I am determining the biogenic signature SDB produces over a range of conditions. This dataset will allow us to greatly refine our take on the role of sulfur disproportionation in both modern and past environments.

**Figure 1:** History of Atmospheric Oxygen Through Time. The red curve represents the classical “two-step” view of the evolution of atmospheric oxygen, here expressed as a percentage of present levels. The green box represents the estimated timeframe for the advent of oxygenic photosynthesis, the blue lines are major global glaciations, and the brown line corresponds to the Cambrian explosion. (Modified from Lyons et al., 2014.)

**Figure 2:** The Sulfur Cycle. At left, a simplified schematic of the sulfur cycle highlighting the main input flux (rivers) and outputs (via sulfate and sulfide minerals) of the ocean. The blown-up section on the right shows modern marine sedimentary sulfur biogeochemical cycling, with a focus on microbial sulfate reduction (red arrow and red box), and sulfur disproportionation (blue arrows). Here, only sulfite disproportionation is shown for the sake of simplicity, but thiosulfate and elemental sulfur disproportionation are also part of this cycling. These intermediate sulfur species arise from the oxidation of sulfide. Fluxes out of the system include pyrite (FeS$_2$) and barite (BaSO$_4$) burial. (Modified from Fike et al., 2015.)
A Project of One’s Own
Four graduates share the thrills and challenges of writing a senior thesis

I t can be a challenge: the inability to predict what one’s research will reveal, the anxiety surrounding translating those findings into a cohesive paper, and the need to balance a massive research project while still taking classes. Yet each year, four to 10 EPS seniors bury away—in the “fishbowl” office on the fourth floor in the Geo Museum, in libraries, or in their dorm rooms—to write their senior theses. Paired with faculty thesis advisors and aided in the nuts-and-bolts of thesis management by department preceptors Esther James and Annika Quick, these students often spend the summer after junior year in the field or in the lab, then launch into their last year at Harvard with one giant deadline: the senior thesis due date in early April.

Topics range from studying atmospheric pollution and climate change, to the origins of life, to the workings of the Earth’s core and our magnetic field. Sometimes EPS students’ theses have proven valuable in practical terms: for example, one former student’s thesis contributed to identifying a new, active fault system beneath metropolitan Los Angeles and another’s research will be used by department preceptors Esther James and Annika Quick, these students often spend the summer after junior year in the field or in the lab, then launch into their last year at Harvard with one giant deadline: the senior thesis due date in early April.

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But most often, results are more nuanced; triumphs, more personal. Here, four senior theses—writing alumni—Esther Kennedy ’13, Matt Luongo ’17, Valerie Shen ’14, and Sam Goldberg ’17—share their senior thesis reflections.

ESTHER KENNEDY
“The only way to find out if something is worth measuring is to measure it.”

Esther Kennedy’s thesis research resulted in a surprising observation. Studying the limestone of Jones Ridge, on the Alaskan border with Canada’s Yukon Territory, she found two “bumps” revealing differences in carbon values (suggesting biological activity) in the rock layers—one of the bumps unexpected and not recorded elsewhere in the world. Yet without other rock sections to compare it with and with fairly inconclusive other measured isotopes, Kennedy couldn’t be sure whether that signal was just a local blip or something more significant.

Looking back, she says, “I feel like there’s this perception that your thesis is going to be groundbreaking. And this wasn’t.” But her ambiguous findings did not daunt her: “I came out of the process feeling really committed to geology,” she says.

“The only way to find out if something is worth measuring is to measure it,” she notes. “My thesis was the defining event of college for me; I think what stands out most to me is that it was the first time I ended up learning so much about a topic. As an undergrad you don’t ever have thoughts that your advisors haven’t already had, but my thesis was still my first opportunity to think: ‘Oh, I am the one who gets to think about this. I am the one who gets to interpret this.’ And there just aren’t other opportunities to do that in college in that big of a way.”

Kennedy knew from freshman year that she was interested in fieldwork, and the summers after sophomore and junior years found her in her home state of Alaska as a field assistant to then-PhD student Justin Strauss (now an assistant professor of Earth sciences at Dartmouth College) who worked with Kennedy’s academic advisor, Professor of Earth and Planetary Sciences Francis Macdonald. (Her thesis advisor was Professor of Earth and Planetary Sciences Dave Johnston.) Kennedy returned to Harvard as a senior to write “The Sedimentology and Chemostratigraphy of the Jones Ridge Limestone: High Resolution δ13C and Δ34S Measurements from the Steptoan Positive Carbon Isotope Excursion,” enjoying the community of EPS graduate students and fellow undergraduates working on their theses “with steadily increasing frequency over the course of the year” in the Geo Museum office.

For the past three years, Kennedy has drawn from her geology background as an environmental specialist for the Sitka Tribe...
of Alaska, in Southeast Alaska, working on subsistence food sources, specifically in the areas of ocean acidification monitoring and shellfish toxin testing. Eventually, she plans to attend graduate school for a master’s degree in modern oceanography.

“There is so much room for interpretation or for competing narratives in resource management—it’s the same type of uncertainty that attracted me to geology,” she says.

**MATT LUONGO**

“I didn’t think I’d become so obsessed.”

For “Comparison and Calibration of Climate Proxy Data in Medieval Europe,” Matt Luongo, a joint EPS and environmental engineering concentrator, analyzed scientific and historical proxies for climate in Western Europe between 1000 and 1426 CE. Working from historical databases that contained both direct and implied descriptions of climate events, such as monastic weather journals, harvest tax records, or billing records regarding rebuilding infrastructure after a serious weather event, he was able to correlate historical climate reports with natural paleoclimate proxy data contained within tree rings, ice cores, lake cores, and stalagmites.

“My thesis was focused on trying to compare these two types of proxies—historical and scientific—and then calibrate them statistically to see if we can come up with any meaningful metrics between the two that tell us something about how to read climate proxy data,” he says.

“What we discovered was that if you have a significantly hot and dry year, you can with statistical certainty see it in both the historical and the scientific proxies. So that was pretty cool.” The standout hot and dry year was 1137 CE; Luongo was able to delve into it in his thesis.

Luongo’s advisors were Francis Goelot Professor of Medieval History and Chair of Harvard’s Initiative for the Science of the Human Past (SoHP) Michael McCormick and Professor of Earth and Planetary Sciences and of Environmental Science and Engineering Peter Huybers; Luongo drew on McCormick for historical and writing support, and Huybers for science and statistics.

“I think everyone who writes a thesis has a different process,” Luongo says, noting that his project involved “gathering the data and making the data usable and readable for me. And then meeting with my advisors every week and throwing a bunch of stuff at the wall and seeing what sticks. ... I had my final idea of what I wanted to do, but I had no idea how I was going to get there.”

Luongo cites time management as one of the skills the thesis process refined:

“Balancing your final goal with where you were on that day, and then making sure you weren’t going too far down the rabbit hole on one little thing. ... You have to keep the big picture in mind. ... And you also need to remember that it does take time to write.”

“For me, honestly, the hardest part was doing my other classes because I wanted to be working on my thesis instead,” he says. “I didn’t think I’d become so obsessed.”

Now an energy and utilities consultant in New York City, Luongo says that the thesis experience made him “a much better scientist and researcher because of reading through papers, making up my own methodologies to do something that was novel, asking questions, and rejecting things that I didn’t think were correct.”

**VALERIE SHEN**

“It was not normal and is not really suggested.”

Valerie Shen’s senior thesis experience also didn’t involve fieldwork or time in the lab, and she also managed to both research and write her thesis during her senior year.

As a joint EPS and environmental science and public policy concentrator with a secondary in economics, Shen spent the summer before senior year interning at McKinsey & Company in San Francisco. It wasn’t until she returned to campus that she and her advisor, Sturgis Hooper Professor of Geology and Professor of Environmental Science and Engineering Dan Schrag, determined her topic: researching theories for why global average surface temperatures did not increase as anticipated between (roughly) 1998 and 2012—nor as they had prior to 1998.

From the perspective of scientists, the temporary pause in temperature increases was no reason to question the general trend of global warming, Shen explains. “But from a public relations perspective, and a policy-setting perspective, it was really important because all of the climate deniers now had something to grasp onto.”

Her thesis—“Cause of the Pause: Exploring the 21st Century Global Warming Hiatus”—surveyed theories as to why surface temperatures increases paused, compared those theories and arguments, and explored responses by the scientific community and the policy implications. It combined two areas Shen cares deeply about: climate and policy.

Regarding sorting out her topic in the fall of senior year, Shen says, “It was not normal and is not really suggested.” In her favor were the fact that she had assisted Schrag on clumped isotope thermometry lab work as a sophomore and junior, and the fact that she accepted a postgraduation job offer early in the fall and could focus on her thesis during the remainder of her senior year. In addition, Shen says, “I had the best possible advisor for it, and the best possible topic for me.”

She described her relationship with Schrag as “tough love,” adding that his approach was “exactly what I needed, partially because I’m really bad at doing things when there isn’t a deadline, and with a thesis, it’s not really like there are deadlines that are coming up all the time. The only deadlines were the meetings that we had, and it was important for me to know that if I wasn’t prepared for the meetings, he was definitely going to call me out.”

Now in her first year in a joint MBA and Master in Environment and Resources program at Stanford following several years working at McKinsey & Company and G2VP, Shen encourages students to explore writing a thesis and to keep their schedule open to the possibility, even if they are not sure. “I’m really glad that I did it. I feel like having engaged in a project like that is a really important part of your educational experience. And it would have been a shame if I had left Harvard and didn’t take advantage of all those resources.”
WORDS OF WISDOM

In 2016 the department began a new tradition of asking seniors for advice that could be passed along to the next generation of thesis writers. Their words of wisdom along with their photos are collected and displayed in posters that hang in the Geo Museum’s “fishbowl” thesis-writing office.

Stay organized from the beginning. Using a citation manager like Mendeley and keeping everything hyperlinked and cross-referenced in Word will save you a ton of time during your final deadline push. Also make the thesis office your home, but remember to leave at least once a day.

Forrest Lewis’17
EPS-Environmental Science and Public Policy

Try to finish your research early; writing takes longer than you think. If at all possible, finish lab work before winter break, and leave yourself that month to analyze your data, make figures, and write your thesis. Two random pieces of knowledge that I learned later than I should have: 1) Don’t manage your references by hand. Download Mendeley (which is free), which will store and format all of them for you, and [which] imports text directly into Word. 2) Microsoft Word can automatically generate a table of contents that updates when you make edits. Lastly, writing a thesis is hard and you’re doing incredible work, so remember that and keep your chin up! You’re going to do great!

Alyssa Chan ’16
EPS-Chemistry

Take however much time you think a section of your thesis will take to complete. Triple it. That’s how much time it will actually take.

Tyler Barringer ’16
Engineering Sciences-EPS

As with Shen and Luongo, Goldberg’s senior thesis led him to graduate school: he is now in his second year at MIT studying fluvial geomorphology, with a focus on continent-scale drainage patterns and river network reorganization, in the Department of Earth, Atmospheric, and Planetary Sciences. He is also working on a project studying the climatic setting of early animal evolution.

“One of the reasons I did a senior thesis was I wasn’t sure whether I wanted to go to grad school and I thought it would be a good way to get a taste to see what it would be like,” Goldberg explains.

“The presentations of senior theses are an annual celebration of the diversity of research efforts brought together under the umbrella of EPS.”

—JOHN SHAW
EPS DEPARTMENT CHAIR

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In the second part of his work, Goldberg used a database of tropical and subtropical sea level records (i.e., far away from the ice sheets driving these changes) in an attempt to reconcile misfits and apparent contradictions between different locations.

"What that ended up turning into was an exploration of the importance of lateral variability of earth structure, which explains the misfit found using a traditional spherically symmetric model," he says, explaining that although geophysicists know that the Earth exhibits lateral heterogeneity, his project specifically explored the role of such heterogeneity in solid earth deformation in response to changing ice and water loads. "This has implications both for past sea-level changes (and other earth deformation processes) as well as trying to predict future sea-level change from anthropogenic global warming."

Goldberg had a good relationship with his thesis advisor, Frank B. Baird Jr. Professor of Science Jerry Mitrovica ("I like the way he thinks about science"), and his faculty advisor John Shaw, Harry C. Dudley Professor of Structural and Economic Geology and EPS department chair. But the research and interpretation process weren’t always easy. "Not everything I tried ended up being successful," he notes, explaining that it wasn’t until January that his project began to have a recognizable form and conclusion.

Despite—or because of—the challenges, Goldberg recommends writing a thesis. "It’s the best way to get to know the professor, to get to know the science, and to come up with something that is your own finished project. There aren’t a lot of other experiences like that in undergraduate programs."

>> Cathy Armer

MGM SHOWCASE

The Mineralogical and Geological Museum at Harvard (MGMH) is widely known for its vibrant displays in the Harvard Museum of Natural History as well as for its unique specimens collected since the museum’s inception over 200 years ago. Less known is that MGMH is also a contributor to and resource for a variety of gemological, mineralogical, and meteoritic research. On a wider level, the MGMH works with IAGeo Ltd. to identify new mineral standards and to supply the research community with accurate and reliable calibration standards for research.

Frank Keutsch, Stonington Professor of Engineering and Atmospheric Science, professor of chemistry and chemical biology, and EPS affiliate professor (see page 9), has been working with MGMH’s Curator Raquel Alonso-Perez on numerous projects, and Keutsch recently donated several new specimens, including type specimens (reference samples by which a mineral is defined) that he has discovered. One example is Keutschite from Uchucchacua mine in Oyón province, Peru, shown here.
Kaighin McColl to Join EPS
The department is delighted to name new assistant professor

Coming from Australia, where it basically never snows, I’m amazed by how good the prediction of these snow events is,” Kaighin McColl said a few days following the Boston area’s “bombogenesis” event in early January 2018.

McColl, a hydrologist with a particular focus on land-atmosphere interactions, will start as an assistant professor of Earth and planetary sciences in the Faculty of Arts and Sciences and as an assistant professor of environmental science and engineering in the John A. Paulson School of Engineering and Applied Sciences in July. But he has lived in Massachusetts long enough to know that weather forecasting in New England is far from a perfect science. He acknowledges that forecasters “often get it wrong,” but he is nonetheless impressed with their ability to warn residents of a big storm and the resultant early school and business closings, road crew preparation, and other accommodations.

Part of McColl’s appreciation might reflect the fact that he has spent most of his life in Australia and came of age during the worst drought in that country’s recorded history, the Millennium Drought. It also might reflect the timeline and detail of his academic focus: working with satellite data of microwave radiation that indicates and measures moisture in the top 5 cm of soil, McColl studies interactions between the land surface and the atmosphere. His findings may eventually be used to improve forecasts of droughts, floods, and heatwaves, and may ultimately help the human response to the physical, public health, social, and geopolitical impacts that extreme weather events can have.

McColl wasn’t always interested in weather or satellite data. Born in Ithaca, NY, where his father was studying at Cornell, he was raised in Geelong, Australia, about an hour’s drive from Melbourne. In college, he thought he would focus on math, but undergraduate work in a bioinformatics lab studying the genomes of Australian mammals (in particular, marsupials such as the platypus, wallaby, and opossum) piqued an interest in research and revealed a desire for real-world impact.

He graduated from the University of Melbourne with a “double degree,” two bachelor’s earned in five years: a BE in environmental engineering, which “largely meant hydrology,” and a BS in applied math. A final project on a salt pan in the Australian desert introduced him to satellite observation and microwave soil moisture retrievals. “I still think it’s remarkable that you can measure these things from space,” he says of the satellite data. The project “combined very practical, real-world problems with the more aesthetically pleasing things I liked about mathematics. I liked that combination.”

After a few years as a hydrologist in the private sector in Australia, McColl enrolled at MIT in 2012 to pursue a PhD with Dara Entekhabi, a hydrologic scientist working with satellite observations of the water cycle who is head of NASA’s Soil Moisture Active Passive (SMAP) satellite mission to study soil moisture globally. McColl was able to further his investigation into the interface between land surface and atmosphere, and he was present in 2015 at the launch of the SMAP satellite from Vandenberg Air Force Base, in California, and later that year he visited field sites on the Tibetan Plateau as part of a collaboration with colleagues at Tsinghua University in Beijing—two career highlights.

After completing his PhD in 2016, McColl came to Harvard as a Ziff Environmental Fellow in the Harvard University Center for the Environment, working with Zhiming Kuang, Gordon McKay Professor of Atmospheric and Environmental Science, collaborating with Kuang and another Harvard postdoc, Giuseppe Torri (see page 18), who is leading a project modeling the land and atmosphere as a coupled system, letting them interact with each other.

“The neat thing about this work is that clouds are included in these simulations—usually they are only roughly included in climate models and are a major source of uncertainty—but they can have a big impact on land surface hydrology,” McColl says.

As an assistant professor, McColl will teach an undergraduate hydrology course, and he looks forward to continuing his work with Kuang and also collaborating with EPS faculty Marine Denolle and Peter Huybers, among others. And with a home already established with his partner, Sarah, an artist who works at a library at Boston College, and their dog, Beulah, McColl will likely have plenty of opportunities to experience more Boston weather and weather forecasting.
Two New EPS Faculty Affiliates Announced

Frank Keutsch and Elsie Sunderland welcomed to the department

The department welcomed two new affiliate professors—Frank Keutsch and Elsie Sunderland—in spring 2018.

FRANK KEUTSCH

Frank N. Keutsch, Stony Brook Professor of Engineering and Atmospheric Science and professor of chemistry and chemical biology at Harvard’s John A. Paulson School of Engineering and Applied Sciences (SEAS) and Faculty of Arts and Sciences (FAS), joined Harvard as a faculty member in 2015 and was appointed an affiliate faculty member of EPS this spring. Prior to coming to Harvard, Keutsch was Tullock Professor of Chemistry at the University of Wisconsin–Madison as well as a visiting professor at the University of Innsbruck, Austria.

His research combines laboratory and field experiments with instrument development to investigate fundamental mechanisms of anthropogenic influence on atmospheric composition, within the context of impacts on climate, humans, and the environment. He is particularly interested in how anthropogenic emissions, e.g., of nitrogen oxides or sulfur dioxide, or altered biogenic emissions from land-use change affect the reactive carbon cycle, as well as the resulting impacts on ozone and aerosol formation on human health and climate.

In addition to his ongoing research in atmospheric chemistry, Keutsch pursues his interests in hiking, playing the piano, and mineralogy—where he has found and described multiple new minerals (see page 7).

ELSIE SUNDERLAND

Elsie M. Sunderland, who is the Thomas D. Cabot Associate Professor of Environmental Science and Engineering at SEAS and in the Department of Environmental Health in Harvard’s T. H. Chan School of Public Health, was awarded tenure this past spring and also appointed an affiliate faculty member of EPS. Prior to coming to Harvard in 2008, Sunderland worked for the US Environmental Protection Agency in Washington, DC, in the Office of the Science Advisor, the National Center for Environmental Research, the National Center for Environmental Economics, and the Office of Science Policy.

Research in Sunderland’s lab focuses on how biogeochemical processes affect the fate, transport, and food web bioaccumulation of trace metals and organic chemicals. Her group develops and applies models at a variety of scales ranging from ecosystems and ocean basins (e.g., the Gulf of Maine, the North Pacific and Arctic Oceans) to global applications to characterize how changes in climate and emissions affect human and ecological health, and the potential impacts of regulatory activities. Sunderland’s group also makes key measurements of chemical concentrations and reaction rates in environmental samples (natural waters, sediments, aquatic biota) and humans (hair, blood) to parameterize and evaluate environmental models.

Outside of work, Sunderland enjoys spending time with her family, long-distance running, watching British comedy, and discussing the merits of Canadian culture.

Ulrich Petersen died November 17, 2017, in Belmont, MA, just two weeks shy of his 90th birthday. He was born in Negritos, Peru, and studied mining engineering at the Universidad Nacional de Ingeniería (1945–1949). From 1949 to 1951 he worked for the National Institute of Mining Research and Development in the Collaborative Mission with the United States Geological Survey (Peruvian Geological Survey). Between 1951 and 1963, he was employed by Cerro de Pasco Corporation, achieving the rank of chief geologist in charge of exploration and mines.

He initiated systematic scientific research projects at all the Cerro de Pasco mines and annual meetings for all mine and exploration geologists. During this period, he obtained his MS (1956) and PhD (1963) from Harvard University. In 1963, Ulrich was invited to join the Faculty of Arts and Sciences at Harvard, becoming the H.C. Dudley Professor of Economic Geology in 1982 and head of the environmental science and public policy concentration in 1993. He was a professor at Harvard for 33 years until his retirement in 1996. During this time, he was invited to serve as a visiting professor at Heidelberg University, Germany, and at the University of California, Berkeley. In addition, he continued to work as a private consultant for the Buenaventura mining company in Peru, and for many other mining companies and nongovernmental organizations in the Americas, Europe, Africa, and Australia.

Ulrich is the coauthor, with H.D. “Dick” Holland, of Living Dangerously: The Earth, Its Resources, and the Environment and, with Dick Holland and Robert A. Rich (SEG 1975 SF), of Hydrothermal Uranium Deposits. Ulrich, his doctoral students, and his colleagues are coauthors of numerous scientific publications on diverse types of ore deposits in Peru and elsewhere.

Due to his initial fieldwork in mine geology in Peru, Ulrich had a special interest in precious and base metal mineralization in veins, and he developed methodologies that led to practical applications in defining hydrothermal fluid pathways at the vein and district scale. Ulrich was an active member of the Society of Economic Geologists (SEG 1964 HF), serving as president of the society in 1988. In 1974, he was named Thayer Lindsley Visiting Lecturer, and in 1996 he was chosen as the SEG International Exchange Lecturer. Ulrich was a fellow of the Mineralogical Society of America, and received Germany’s Humboldt Foundation Research Award. In 1968, Ulrich received from the Peruvian government the Order of Merit for Distinguished Services in the rank of commander for his contributions to knowledge and publications on the geology of mineral deposits in Peru.

Ulrich is survived by his wife of 35 years, Eileen (née Bourque), brother, C. Richard Petersen, son Erich Petersen, daughter Heidi Petersen Loh, and Eileen’s children. He was predeceased by his first wife, Edith Martensen, and son Armin Petersen. Contributions to the Villa La Paz Foundation are welcome (www.villalapazfoundation.org).

This text is adapted from an article by Ulrich’s son Erich Petersen (SEG 1986 F) and his brother, C. Richard Petersen, published in the Society of Economic Geologists newsletter.
At the end of the 1998 movie Deep Impact (spoiler alert!), a comet crashes into the Atlantic. A tsunami drowns Tea Leoni, along with much of the world's population.

At the end of the 1998 movie Armageddon (spoiler alert!), a team (including Ben Affleck) lands on an asteroid headed for Earth and blows it up. Affleck and Earth are saved.

Armageddon was the bigger hit. However, “The science in Deep Impact was more accurate—they got the tsunami exactly right,” says David Allen Kring PhD '89, who reviewed the science in both movies for the Arizona Daily Star and Tucson Citizen. Disagreeing with the father of the H-bomb, Ed Teller, Kring says trying to save the Earth by blowing up an asteroid is a bad idea.

“All those pieces will just keep heading to Earth,” he says.

“You have to deflect objects, not blow them up,” he continues. “Move them to a new orbit. And the farther they are ... from Earth when you try, the less force you need to nudge them. Over the years and decades, the distance created by the nudge will grow.”

Right now, says Kring, the most popular technique under discussion for avoiding asteroid Armageddon (a real one) is “cratering”: shooting a rocket into the asteroid to produce a crater on one side, changing its shape and thereby its orbit.

Kring knows asteroids, comets, and what happens when they crash into planets and moons. In 2000, Kring had an asteroid named after him by the International Astronomical Union. Before it was Kring, it was asteroid 8391, with an estimated diameter of 10 to 15 kilometers, comparable to the asteroid that created the Chicxulub impact crater that killed the dinosaurs (along with most life on Earth) about 65 million years ago. Naming a similar-sized asteroid after Kring was no accident. The fact that the asteroid that created the Chicxulub crater was responsible for the Cretaceous-Tertiary (K-T) mass extinction was proven by (spoiler alert!) David Kring.

David A. Kring: Disaster Scientist

Discovering the cause of the K-T mass extinction

“It’s important to bring together diverse looks at important problems. That’s what EPS does.”

~DAVID KRING PHD ’89

It happened this way: One day, at afternoon tea in Hoffman Labs, Kring listened as Professors Andy Knoll and Stephen J. Gould discussed the K-T extinction event and Nobel-winning physicist Luis Alvarez’s idea that it was linked to a massive comet or asteroid impact ... somewhere. The conversation stuck in Kring’s mind after he finished his dissertation with his advisor John Wood (Stein Jacobsen and the late Rick O’Connell were on his thesis committee) and Kring left...
An artistic rendering of a dinosaur that is soon to be a casualty of the impact responsible for the Cretaceous-Tertiary (K-T) mass extinction about 65 million years ago.

to work at the University of Arizona. There, William Boynton, professor of cosmochemistry and geochemistry, and graduate student Alan Hildebrand were working on the K-T problem through chemical means, and not getting far.

Kring, inspired by his undergraduate work at Indiana University studying Apollo’s Moon rocks and his PhD work at Harvard studying meteoritic fragments of asteroids, suggested looking at the problem petrologically. In 1990, he and Hildebrand went to Haiti and found immense deposits of impact debris. In Europe, for example, the debris was 1 mm thick; in Haiti, it was 46 cm. Accordingly, they started looking for circular structures in the area that would mark the presumed impact. Boynton and Hildebrand were interested in the Colombian basin, says Kring, “because the geochemistry said oceanic crust. I disagreed.” His analyses indicated a continental impact site, like Chicxulub.

Fortuitously, Pemex, the Mexican national oil company, had been drilling in the Yucatán and bringing up rock fragments. Kring asked Pemex for samples; he got two thumb-sized rocks: one igneous, the other breccia (rock made up of fragments of older rock). Kring saw they had been shock-metamorphosed and melted in a way that could only have been produced by an impact event. “We proved it was an impact crater.”

Last year was the 25th anniversary of the discovery of the Chicxulub impact crater. And last year was big for Kring in other ways. He and an international team drilled into the peak ring of the Chicxulub crater to test his group’s model of peak-ring formation and impact-generated hydrothermal systems. To mark the anniversary of the crater’s discovery, Kring created a library containing pictures and illustrations to help scholars around the world discuss Chicxulub and related K-T boundary issues.

In addition to his terrestrial geologic studies, Kring continues to work with NASA to develop new human exploration opportunities on the Moon, and he founded the Center for Lunar Science and Exploration (a collaboration between the Lunar and Planetary Institute and the Johnson Space Center). Kring also continues to worry about spotting potentially dangerous asteroids.

“Ideally, you’d like to know an asteroid is heading our way 100, 150 years in advance. We just need to continue enhancing our survey program,” he says, noting that the 2013 Chelyabinsk asteroid, which caused 1,500 injuries and lots of structural damage, was a “weak, stony asteroid, and so didn’t reach the ground.” If it had, things would have been much worse. But no one saw it coming.

“There are millions of small impactors that can destroy cities that are not discovered,” he says.

This year also marks 30 years since Kring completed his PhD, and he looks back fondly to his days at EPS: “Everybody trying to address fundamentally important science questions. That’s a culture that doesn’t exist everywhere.

“When I was at the [then] geology department, at 3 pm, tea on the top floor of Hoffman, we would sit down and talk about a topic for four, five days. We were discussing new science as it appeared.

“I still communicate regularly with Andy Knoll, and people ask: Why are you talking with a paleontologist? Well, it’s important to bring together diverse looks at important problems. That’s what EPS does.

“That should be treasured.”

>> David Rosenbaum

Caring for Natural—and National—Treasures

Danielle Lehle works to protect the natural resources of our national parks

When Danielle Lehle ’07 describes her work for the National Park Service (NPS), two points become clear instantly: her love of national parks, and the variety of skills and knowledge her position requires.

Currently a Presidential Management Fellow in a two-year position as a natural resource specialist at the park service and based in Lakewood, CO, just outside Denver, Lehle looks at park management issues—encompassing everything from visitor experience to erosion, to invasive species, to five-year strategic plans—at the parks, monuments, historic and military sites, recreation areas, and trails that fall under NPS care.

Describing her office as akin to an “in-house consulting group” for the NPS, Lehle tells of projects ranging from addressing the visitor experience at Cabrillo National Monument, a 160-acre national park outside San Diego, CA, known for its tide pool homes of anemone, limpets, sea stars, and barnacles, to strategic planning at the Carl Sandburg Home National Historic Site in the mountains of North Carolina, collaborating with the staff to determine how the poet’s house and dairy farm should be maintained. Other projects include work with Everglades National Park, with the Civil War battlefield at Pea Ridge, AR, and with San Antonio Missions National Historical Park in Texas.

“Our involvement ranges from facilitating preliminary meetings up to actually writing the plan itself,” Lehle says. “So for many projects I write up sections involving natural resources (biological, geological, air, water, soundscapes), describing what the current condition of the resource is, and how those conditions will change if the park implements certain actions, based on research and professional judgment.”

“It was a good lesson in how old our subject is and yet how young the field is.”

—DANIELLE LEHLE ’07

It’s challenging work, but personally fulfilling. “I really care about management of national parks,” Lehle says. “National parks protect some of the most inspirational, beautiful, historic, and unique places of the country.”

“Drumline is a big thing in Texas. That was my life in high school,” she says, adding that her high school drumline team won three national championships. In the marching band drumline in the fall, Lehle was a mallet player, playing bells, xylophone, vibraphone, and marimba. Spring semester saw her in percussion ensemble in concert band, playing a wider variety of drums.

Percussion continued at Harvard, where Lehle was a member of the Harvard-Radcliffe Orchestra and the Harvard Pops Orchestra, subbed for the Bach Society Orchestra and Mozart Society Orchestra, and co-directed the Harvard Undergraduate Drummers, a student-run percussion ensemble. It was a big commitment: she recalls the challenge of completing her senior thesis while practicing for a major concert, the former—an earthquake hazard assessment of the Los Angeles basin, which later won the Hoopes Prize—due the day before the performance.

She was also active at Eliot House, and found EPS—her focus was geology—spring of freshman year when an across-the-hall neighbor “dragged” her to EPS 8, History of the Earth. “I was hooked,” Lehle says. (The neighbor, Scot Miller, also a 2007 EPS graduate, returned to Harvard for his PhD with Steve Wofsy, graduating in 2015. He’s now an assistant professor at Johns Hopkins University.)

Lehle has fond memories of EPS: field trips, 3 pm cookies, the Geosociety, and of course, EPS 8, remembering her professors, Paul Hoffman and Dan Schrag, occasionally disagreeing over theory or results of a study. “One of them would be lecturing, and the other one would say, ‘No, actually, that’s not correct. That’s been updated.’ It was a good lesson in how old our subject is and yet how young the field is,” she says.

After graduation, Lehle worked for several years as a park ranger in Grand Teton National Park and as a technician for the Utah Geological Survey—seasonally complimentary jobs that allowed for a lot of skiing, she notes. A desire to learn more about natural resource management led her to Yale University’s School of Forestry & Environmental Studies (F&ES) where she earned a master’s degree in environmental management and a certificate in ecosystem conservation and management—and, of course, played percussion in Yale’s student orchestras.

Two short-term jobs followed as she put her energy into applying for a position at the NPS, which is notoriously difficult to enter. Being named a finalist for the Presidential Management Fellows Program opened the door.

With about four months remaining in the fellowship as Earth & Planetary Times hits the press, Lehle’s dream is to remain at the park service. “I’m crossing my fingers; I’m hoping to get converted into a longer-term position in this office,” she says. “I work with a lot of great people, and I get to work on a lot of great projects with parks around the country.” Another reason to want to stay: she’s again playing percussion, this time for the Lakewood Symphony Orchestra.

>> Cathy Armer
To understand how bacteria interact with—and record—their environment, one must understand what happens intracellularly: we need to go from the scale of a global ocean down to that of a bacterial cell.

So how do these metabolisms work? DSR sequentially reduces sulfate to sulfide (Figure 3). Each reaction bears a specific isotopic signature, and is promoted by the activity of a specific enzyme. The net isotopic signature produced by the whole reaction sequence is a composite of these individual reaction-specific effects. The architecture of the DSR reaction network, and the nature of each reaction composing it, has been intensively studied. This has allowed building models linking enzymatic activity, physiology, environmental conditions, and sulfur isotope fractionations. Similar information for disproportionation remains a mystery, despite both metabolisms sharing most of their reactions. With the explicit models built for DSR in hand, the next step in my research is to adapt those to reflect disproportionation, and to provide links to intracellular dynamics.

Similar to DSR, these disproportionation reactions are driven by enzymatic activity: to understand how these enzymes work, and how they give rise to the metabolisms we are interested in, we need to go down to the molecular level.

Enzymes are macromolecular biological catalysts: they accelerate chemical reactions that would otherwise take too long to sustain a cell. Their specific role inside a cell is set by a genetic sequence that gives rise to a three-dimensional structure adopted by a protein. Enzyme architecture determines function, and then, in series, promotes a reaction. Further, enzymes carry a specific sulfur isotopic signature. The enzyme-specific isotopic signature is the scaffold upon which the reaction isotopic effect builds. For instance, dissimilatory sulfite reductase, which catalyzes sulfite reduction in DSR, has been extensively studied (Figure 3): its structure informs the key reaction it promotes. The additional determination of its isotopic effect was a huge step forward in understanding the molecular underpinning of the DSR sulfur isotopic signature.

SDB carry all enzymes required to perform sulfate reduction, yet, they cannot. Since enzyme structure is central to function and regulation inside a cell, the structure of the enzymes found active in SRB and of those found in SDB might differ. I am currently testing this hypothesis by compiling enzyme protein sequences found in both SRB and SDB to compare their structure. Put differently, it is a protein-level structural difference that may give rise to a new and powerful global-scale biosignature.

Earth’s oxygenation history is complex. Piecing it together from biological, chemical, and geological evidence is crucial. It is essential to consider all scales: proteins are the scaffold upon which entire metabolic pathways are built, these pathways allow bacteria to intimately interact with and record local environmental conditions, in turn linked to global changes. All scales are necessary, and none is sufficient on its own, to enhance our understanding of the history of atmospheric oxygen through time, and by extension, of the evolution of life, all the way to us, here, breathing that oxygen.

To understand how bacteria interact with—and record—their environment, one must understand what happens intracellularly: we need to go from the scale of a global ocean down to that of a bacterial cell.”

—EMMA BERTRAN G5

Figure 3: Reaction Network During Microbial Sulfate Reduction. There are four main reversible reactions in this metabolism: (1) environmental sulfate is taken up by the cell, (2) sulfate (SO₄²⁻) is then activated to adenosine phosphosulfate (APS), (3) then that APS is reduced to sulfite (SO₃²⁻), and finally, (4) sulfite is reduced to sulfide (HS⁻), which is excreted into the environment. The enzymes involved in the four reaction steps are also shown. Each enzyme is made of a number of subunits, as shown in their structure in the schematic. The blown-up enzyme shows the structure of dissimilatory sulfite reductase highlighting its three subunits, A, B, and C, in blue, magenta, and green, respectively. (Figure from Oliveira et al., 2008.)
Faculty

Having served 12 years as divisional dean, Jeremy Bloxham, Mallinckrodt Professor of Geophysics, will conclude his term as dean of science at the end of the 2017–18 academic year. In his letter to the faculty announcing the transition, Dean of the Faculty of Arts and Sciences Mike Smith noted among Jeremy’s many achievements that “he has invigorated undergraduate science education, especially with regard to foundational courses, undergraduate research, and hands-on learning ... [he] drove the creation of FAS Research Computing, which provides stellar computing services and technologies to advance scientific research ... [and he] has been supportive of our collective efforts to increase the representation of women in science, continually advocating for the recruitment and advancement of outstanding scholars.” In the coming academic year, Jeremy will enjoy a well-deserved sabbatical.

Marine Denolle, assistant professor of Earth and planetary sciences, was one of 18 recipients of the 2017 David and Lucile Packard Fellowship for Science and Engineering awarded to the “nation’s most innovative, early-career scientists and engineers.” Each fellow receives $875,000 over five years to pursue their research. Marine’s project aims to develop new strategies to collect and analyze seismic data, create new models that characterize the impact of the groundwater aquifer state on seismic amplification in basins, and predict the evolution of seismic hazard in urban areas.

Paul Hoffman, Sturgis Hooper Professor of Geology Emeritus, received the 2016 Gold Medal of the Royal Canadian Geographical Society for studies on the origin of continents and snowball Earth. Also, in February of this year, at age 76, Paul ran the 50th annual Birch Bay (WA) Marathon (26.2 miles) in 4:41:38, winning the 65+ age division.

Professor of Environmental Science and Policy and Teresa and John Heinz Professor of Environmental Policy John P. Holdren received the 2018 Daniel Patrick Moynihan Prize, awarded by the American Academy of Political and Social Science (AAPSS). This year was the first time that the prize was awarded to a natural scientist. The Moynihan prize recognizes social scientists, public officials, and civic leaders “who champion the use of informed judgment to advance the public good.”

Andy Knoll, Fisher Professor of Natural History and professor of Earth and planetary sciences, received an honorary Doctor of Science from the American Museum of Natural History in New York, conferred at the 2017 commencement of the museum’s Richard Gilder Graduate School.

Alexander Agassiz Professor of Biological Oceanography James J. McCarthy was awarded the 2018 Tyler Prize for Environmental Achievement (shared with Paul Falkowski, from Rutgers). Jim was given this award in recognition of his contributions to “fighting climate change through increasing our scientific understanding of how Earth’s climate works, as well as bringing together that knowledge for the purpose of policy change.”

Harvard’s Climate Change Solutions Fund, now in its fourth year, awarded seven new research projects that Harvard President Drew Faust announced will “generate promising new discoveries and insights that will give communities tools to adapt to our changing climate and help society move toward a clean-energy future.” Jerry Mitrovica, Frank B. Baird Jr. Professor of Science, received funding for his project “Increasing the Adaptive Capacity of Subarctic and Arctic Aboriginal People to Climate and Sea Level Change Using Innovative, Web-Based Informatics Tools,” which aims to create a flexible and collaborative web-based tool for the Cree of western James Bay, Canada, to help adapt to a warming world.

Academic & Administrative Staff

This past October, Tessa Browne started working as Francis Macdonald’s research assistant and lab manager. She graduated from Smith College in May 2017, where most of her research experience was in paleontology.
Benjamin Chauvin, who completed his PhD in France at the University of Lorraine, is now a postdoctoral fellow in John Shaw’s group, creating numerical models to understand the forward development of folds and faults. Benjamin’s thesis focused on structural restoration—recovering the paleogeometry of strata through time using geomechanical numerical methods.

In August 2017, Joanne Choi joined EPS as payroll appointments coordinator. Despite being a “mere two-minute walk from Gund Hall” (she worked in the Frances Loeb Library at the Graduate School of Design for five years), Joanne says, “EPS feels like an entirely new ecosystem.” She adds that she’s “excited to be part of EPS,” and that she “enjoys the welcoming atmosphere and the 3 pm cookies.”

Danielle da Cruz arrived in September 2017 after working as the administrative coordinator for the Midwives at Mount Auburn Hospital. She wears two hats in EPS: one as a lab coordinator supporting Charlie Langmuir and Roger Fu, and another as a field trip coordinator supporting the department preceptors. Danielle notes that she is “grateful to join a department that offers such benefits as First Friday Feast and 5 pm Pizza Fridays (detecting a theme here?).” When not convincing people to hold meetings in her quiet Hoffman office, Danielle can be found tinkering with her bike, lunching on the museum lawn, or picking up chocolate at Cardullo’s. An avid yogini, Danielle aims to bring a lunchtime yoga class to EPS in 2018.

Mark Hoggard joins EPS from a PhD and postdoc at the University of Cambridge, UK. His dissertation was on making observations of surface deflections of the Earth caused by convection in the underlying mantle. He is continuing this research alongside Jerry Mitrovica in EPS and Jacky Austermann at Columbia. In his spare time, Mark likes to travel, climb, and play proper football.

This past March, Department Preceptor Annika Quick defended her dissertation, “Geochemical Dynamics and Nitrous Oxide Release from the Hyporheic Zone of Streams,” and will receive her PhD in geosciences from Boise State University in May 2018.

In September 2017, Angela Rigden joined Peter Huybers’s group as a postdoctoral researcher. Before coming to Harvard she received a BS in biological engineering from Cornell University and a PhD in Earth science from Boston University. Her background is in hydrology, and as a postdoctoral researcher she will be investigating the relationships between the water cycle and agriculture in the context of climate change.

Lei Wang recently obtained a PhD in atmospheric dynamics from the University of Chicago. His dissertation research was focused on the fundamental dynamics of a 20- to 30-day periodic behavior in the storm tracks—a newly identified climatic driver and early warning of extremes. His current research, working with Zhiming Kuang, aims to improve our understanding of the wide variety of scales in the atmosphere to bridge the weather-climate gap, especially the role of moist convection on high-impact extreme weather and climate events.

Lewis Ward ’11 (organismic and evolutionary biology) joined EPS as an Agouron Institute Postdoctoral Fellow in January. He completed his PhD in geobiology at the California Institute of Technology last spring, focusing on microbial metabolic evolution and the rise of oxygen. As a postdoctoral fellow, Lewis will be concentrating on the origin and early evolution of the nitrogen cycle, primarily advised by Dave Johnston.

In June 2017, Yuki Weber joined Ann Pearson’s lab after receiving a PhD in organic geochemistry from Basel University, Switzerland. Yuki is studying the membrane lipids of mesophilic and extremophilic Archaea and their role as paleoenvironmental proxy indicators. His work aims to unravel the underlying mechanisms that control lipid composition in these organisms by means of controlled culturing experiments.

Prior to coming to EPS, Katherine Wiryaman worked as a staff assistant in the Immunology & Infectious Diseases Department at the Harvard T.H. Chan School of Public Health. At EPS she supports three faculty members—Marine Denolle, Rebecca Fischer, and Stein Jacobsen—with administrative needs and grant management.

Simon Lock G6 has accepted the Planetary Science Option postdoctoral fellowship at Caltech and will begin in fall 2018. In addition, Simon is the lead author of a study (co-authored with his advisor Sarah Stewart, professor of Earth and planetary sciences at the University of California, Davis) recently published in the Journal of Geophysical Research: Planets that suggests the Moon emerged from a massive, doughnut-shaped cloud of vaporized rock called a synestia (see above). Along with Simon and Sarah, researchers on the study were Matija Cuk (SETI Institute), Stein Jacobsen (EPS), Zoë Leinhardt (University of Bristol), Mia Mace (University of Bristol), and Michail Petaev (EPS).
GEOCLUB NEWS

At the start of 2018, first-year graduate student Ned Kleiner, beer czar, sent an email to the department alerting members that due to inflation the GeoClub had been forced to raise the price of beer (and cider) from $1.50 to $2.00. This change, he explained, was “to preserve the budget of the GeoClub as well as to make sure that we are able to purchase beverages that we believe people will enjoy.” Ned included with his announcement a graph (at right) that showed the rise in the price of beer between 2007 and 2017, according to the Bureau of Labor Statistics. The y-axis is the percentage of beer prices relative to 1982 (i.e., a beer that cost $1.00 in 1982 would cost about $2.00 in 2007 and almost $2.50 in 2017).

**Graduate Students**

Thirteen graduate students began their first year in the department in fall 2017. We extend a hearty welcome to:
- **Ted Amdur**, Williams College
- **Eliel Anttila**, University of California, Berkeley
- **Mark Baum**, Dartmouth College
- **Matthew Brennan**, University of Chicago
- **Alec Brenner**, California Institute of Technology
- **Junjie Dong**, University of Michigan, Ann Arbor
- **Zachary Eriksen**, Michigan State University
- **Ned Kleiner**, Amherst College
- **Parker Liautaud**, Yale University
- **Tina Liu**, Columbia University
- **Kaitlyn Loftus**, Columbia University
- **Peter Sherman**, Imperial College
- **David Wei**, Peking University

The winners of the 2016–17 Shaler Teaching Award are Kimberly (Kimme) Moore G4, teaching fellow for EPS 52, Global Geophysics: A Primer, in fall 2016, and Lauren Kuntz G5, who won the award for both SPU 29, The Climate-Energy Challenge, and EPS 231, Climate Dynamics, in fall 2016 and spring 2017, respectively. The Shaler Teaching Award is given annually to teaching fellows who exhibit excellence in teaching. Each recipient receives an “Outstanding EPS Teaching Fellow” certificate, an engraved Estwing rock hammer, and $500. Congratulations—and thank you—to Kimme and Lauren.

In addition, six EPS graduate students received the fall 2017 Harvard University Certificate of Distinction in Teaching. Awarded by the Bok Center for Teaching and Learning, this award is given to outstanding teaching fellows and assistants who earn an overall score of 4.5 or higher out of 5.0 (with a minimum of five evaluations) on the Q evaluations completed by students in their courses. Recipients were honored by the Bok Center at a reception in April.

**Sophie Coulson** G2, EPS 10, A Brief History of the Earth

**Jessica Don** G3, EPS 171, Structural Geology and Tectonics

**Lauren Kuntz** G5, SPU 29, The Climate-Energy Challenge

**Kimberly Moore** G4, EPS 10, A Brief History of the Earth

**Sunyoung Park** G6, Freshman Seminar 231, GeoSciFi Movies: Real vs. Fiction

**Tamara Pico** G4, EPS 10, A Brief History of the Earth

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**ON THE WINDOW SILL**

Over the years, the EPS community has used the Hoffman Student Lounge window sill as an ad hoc Goodwill repository. Everything—no matter how ... odd—quickly finds a new home. Some recent items that have come and gone have included:

- **Standard Methods of Chemical Analysis**, volumes 1–3, edited by F.J. Welcher
- Several rocks
- **The Life-Changing Magic of Tidying Up**, by Marie Kondo
- A ceramic pie plate with a recipe for cherry pie
- Eight red, gold-rimmed wine goblets
- **Radioactive Dating** (one staff member asked if this book was for scientific or social purposes)
- A box of library catalog cards
- A potted hibiscus, wilted
- A Viking helmet, scary

At the start of 2018, first-year graduate student Ned Kleiner, beer czar, sent an email to the department alerting members that due to inflation the GeoClub had been forced to raise the price of beer (and cider) from $1.50 to $2.00. This change, he explained, was “to preserve the budget of the GeoClub as well as to make sure that we are able to purchase beverages that we believe people will enjoy.” Ned included with his announcement a graph (at right) that showed the rise in the price of beer between 2007 and 2017, according to the Bureau of Labor Statistics. The y-axis is the percentage of beer prices relative to 1982 (i.e., a beer that cost $1.00 in 1982 would cost about $2.00 in 2007 and almost $2.50 in 2017).
“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 here.

“I did a lot of baking … I was in Idaho, doing a lot of research and had no friends.”

“I would like to cite myself here.”

“Did you see how they calculated that the methane was geogenic?”

“When I got home the other night my wife said to me, ‘I almost made brownies for you for Valentine’s Day.’”

“If it doesn’t work for magnesium then you know we have a problem.”

“These are contour maps—drawn by hand!”

“Say what?!”

“Why are there so many two-letter acronyms in chemistry? I’m sick of it.”

“He’s a fun spirit to have around … once every six months.”

EARTH BOWL MMXVII

Last November, on a chilly autumn night (temperatures dropped to 28 degrees and the winds howled over 19 mph) EPS graduate students suited up (warmly) for the third annual Earth Bowl. EPS’s graduate coordinator Sarah Colgan and postdoctoral fellow and EPS FL Commissioner Harriet Lau PhD ’17 officiated over the two-hand-touch football game, which pitted Mean House Effect against Seismic Wave. After two 20-minute halves Seismic Wave prevailed, beating the opposition 35 to 14. Speaking as a team co-captain for the Meanhouse Effect, Tia Scarpelli G2 noted that “in hindsight, we may have focused too much time and energy on making amazing azure blue tie-dyed jerseys and on our mascot, which had music blaring and smoke rockets exploding from the chimney. I don’t regret it though—team morale remains high going into next year!”
In SITU & In SILICO

(1) Last August, 33 graduate students traveled to Wyoming for the annual graduate student field trip. Their nine-day excursion began in Denver, and they then traveled north through southeastern Wyoming, timing their arrival in Big Horn National Forest to coincide with the total solar eclipse on August 21. They spent several days in Yellowstone National Park viewing hot springs, geysers, and fumaroles as well as the many bison in the park. The group also explored, hiked, and swam in the lakes of Grand Teton National Park. For many participants, the trip also included whitewater rafting in Jackson Hole; for those not so inclined, the afternoon was spent visiting a wildlife art museum and exploring Jackson Hole. Here, second-year graduate students James Muller and Aleyda Trevino are wearing solar eclipse glasses sitting on the side of Route 26—somewhere in the path of totality.

(2) Research Associate Giuseppe Torri’s fascination with clouds started in childhood in a small village not too far from the Italian Alps, sparking his curiosity as to how these “beautiful systems formed and what powered them.” Years have passed but the basic question still motivates Giuseppe’s curiosity. Clouds, he explains, are dynamical systems that exhibit great complexity at all scales, from the sophisticated phenomenology of their tiniest constituents, to the interaction with large-scale features, such as the Hadley cell or the Walker circulation. The global models used to study the Earth’s climate do not include clouds in all their complexities, and simplified representations, called parameterizations, are needed. Because clouds are such important components of the climate system, a good parameterization is key to correctly simulate the behavior of the climate over the next few decades. In his work, Giuseppe uses very high resolution numerical models to better understand the basic dynamics of cloud systems. The simulations from these models are useful to test ideas and capture universal behaviors that he hopes will allow him to improve the cloud parameterizations used in climate models.

(3) Last August Stein Jacobsen, professor of geochemistry, above, led a trip to Norway as a part of Harvard’s Origins of Life Consortium, with help from Andy Knoll, Fisher Professor of Natural History. About a dozen students and faculty members of the consortium traveled to Oslo to study the igneous, sedimentary, and metamorphic rock types in southern Norway and to walk through 1,300 million years of Earth history over a few kilometers.
(7) Last summer, EPS concentrator Maya Chung ’19, pictured here presenting her poster at AGU’s Ocean Sciences Meeting this past February, participated in the Summer Undergraduate Research Fellowship (SURF) program at the Scripps Institution of Oceanography, working in the lab of Scripps Institution Professors Lynne Talley and Sarah Gille on the Southern Ocean Carbon and Climate Observations and Modeling (SOCCOM) project. Using the Southern Ocean State Estimate (SOSE), Maya studied the relationship between sea ice export from the Ross Sea and the conditions of the Amundsen Sea Low, and linked them to recently observed freshening events in the Southeast Pacific.

(6) Katie Polik ’18, Barra Peak ’18, and Vlad Sevostianov ’19 visited Joggins Fossil Cliffs, a noted fossil locality situated in a sub-basin of the Bay of Fundy, in Nova Scotia, last summer. The three EPS concentrators traveled to the region to explore the world’s most extreme tidal cycle as well as the geology and paleontology of the area.

(5) Students in John Shaw’s EPS 109, Earth Resources and the Environment, toured the Lackawanna Coal Mine near Scranton, PA. Other stops during the April 2017 field trip included a surface anthracite mine, a wind farm, a solar array, and the opportunity to tour a shale gas drill rig.

(4) Molly Wieringa ’19, who participated in the Juneau Icefield Research Program (JIRP) last summer, celebrates the completion of a bluebird field day at the Matthes-Llewellyn Divide, a topographically flat region where the Matthes Glacier begins to flow south while the Llewellyn Glacier moves north. This is also the approximate location of the US-Canada border.
Graduate Students

Edward S. Grew PhD ’71, esgrew@maine.edu: In October 2017, I was elected a Foreign Honorary Member of the Russian Mineralogical Society in St. Petersburg, the world's oldest currently active mineralogical society (established in 1817), “for outstanding contributions to mineralogy and geochemistry of boron and beryllium and long-term fruitful collaborations with Russian mineralogists.”

The Foreign Honorary Membership has been awarded to only 145 individuals in the society’s history, and I am now one of four US scientists who are current members.

I began learning Russian as an undergraduate at Dartmouth College, and later, while working on my PhD at Harvard, I lived with a Russian family. Spanning the years of 1972 to 1974, I spent 16 months in Antarctica on a winter-over exchange based at the former Soviet research station Molodezhnaya. Because I had studied Russian, I was able to fully appreciate the experience offered by participation in the Soviet expedition to Antarctica that launched my scientific career.


In 2012, Russian mineralologists Evgeny Galuskin and Irina Galuskina named two newly discovered minerals in my honor, edgrewite and hydroxylgedgewite. In 2015 I was awarded the Collins Medal by the Mineralogical Society of Great Britain and Ireland, and in honor of my 70th birthday, the Mineralogical Association of Canada published a special issue of the journal The Canadian Mineralogist with 12 papers by 63 authors representing many of my scientific colleagues from around the world.

K.C. Lee AM ’72, kcoldman@yahoo.com: The following is an update on my interest in fundamental physics. Topics include (1) black holes are dark matter, (2) wormholes, even if traversable, may not solve the black hole information paradox (on both, see John Preskill’s site, Quantum Frontiers, https://quantumfrontiers.com/2013/06/07/entanglement-wormholes/comment-page-2/#comment-82042), (3) a new version of “no drama” at the black hole event horizon (January 18 comment), and, lastly, (4) quantum physics may be a more fundamental description of the universe than is classical physics (January 20 comment, both in Sean Carroll’s blog preposterousuniverse, https://www.preposterousuniverse.com/blog/2018/01/17/beyond-falsifiability/comment-page-2/#comments).

The advantage of working part time is the ability to travel, and in the past year that has included Iceland (not the same as it was in 1971 when we did a spring field trip there), Greenland, Belgium, the Netherlands, Peru, Israel, and Jordan. On the professional front,

The honorary medal Edward Grew PhD ’71 received from the Russian Mineralogical Society (RMS) reads “Mineralogy in All the Space of This Word,” the society’s motto, surrounding an image of quartz crystals. The reverse side reads “All-Union Mineralogical Society” and includes his name and the date of his election to the RMS. The other medal shown here belongs to Robert M. Hazen PhD ’75, and was awarded to him last fall also.

Also, last year Emmaly had a successful transplant of a kidney from a friend of our daughter, Lisa (see the note from Andy Eaton PhD ’75 about the role she played in his wedding). Now we’re looking for a kidney for my son, Jim, who has the same hereditary condition.

Andy Eaton PhD ’75, ade1014@gmail.com: I am semiretired (at least in theory) but still actively presenting talks at water conferences on behalf of Eurofins Eaton Analytical, the largest potable water testing lab in the US. In November 2017, at the Water Quality Technology Conference in Portland, OR, I reconnected with Barry Maynard PhD ’72, thanks to one of Barry’s grad students, and in addition to talking about lead in water we reminisced about the time that Barry’s infant daughter, Lisa, was used as a “prop” at my and Barb’s wedding during grad school days (thanks to my uncle who thought that a shotgun would be a nice touch at the reception).

Andy Eaton PhD ’75 and Barry Maynard PhD ’72 at a 2017 water meeting.

K.C. Lee AM ’72, kcoldman@yahoo.com: The following is an update on my interest in fundamental physics. Topics include (1) black holes are dark matter, (2) wormholes, even if traversable, may not solve the black hole information paradox (on both, see John Preskill’s site, Quantum Frontiers, https://quantumfrontiers.com/2013/06/07/entanglement-wormholes/comment-page-2/#comment-82042), (3) a new version of “no drama” at the black hole event horizon (January 18 comment), and, lastly, (4) quantum physics may be a more fundamental description of the universe than is classical physics (January 20 comment, both in Sean Carroll’s blog preposterousuniverse, https://www.preposterousuniverse.com/blog/2018/01/17/beyond-falsifiability/comment-page-2/#comments).

The daughter of Barry Maynard PhD ’72 made an appearance at the November 27, 1971, wedding of Barb and Andy Eaton PhD ’75. From left to right: Barb’s father, Glenn Shaw; Barb; Lisa Maynard; Andy; Barb’s mother, Mary Perkins Shaw.

Barb and I have also remained in touch with Bob Kamilli PhD ’76, having now shared more than 35 Thanksgivings with Bob and Diana, many of the more recent ones with the late Steve Bushnell PhD ’83 also.

The advantage of working part time is the ability to travel, and in the past year that has included Iceland (not the same as it was in 1971 when we did a spring field trip there), Greenland, Belgium, the Netherlands, Peru, Israel, and Jordan. On the professional front,
I received the George W. Fuller award from the American Water Works Association (AWWA) and the Charlie Carter medal from the National Environmental Monitoring Conference (NEMC) in 2016 and 2017, respectively, both honors that humbled me (a hard thing to do, considering that I won the Bullshotters award my first year of grad school). My greatest accomplishments, however, still remain my children, Brian, a software engineer at Google, and Lauren, a social worker, and my 11- and 8-year-old grandchildren.

David Veblen ’69, MA ’74, PhD ’76, dveblen@jhu.edu: After 33 years of teaching and research, I retired from Earth & Planetary Sciences at Johns Hopkins University. Linda and I fled the overly urbanized northeast corridor and are now living happily on the midcoast of Maine. Most would consider us to be nuts, but we now provide a home for two German shepherds, two horses, seven chickens, seven ducks, and two feral barn cats. The animals keep us busy, plus this part of Maine has some wonderful geology and mineralogy. We have friendly neighbors, including the daughter of the late Phil Osberg PhD ’52 (1924–2016), former geology faculty member at the University of Maine, Orono.

My thoughts turn often to my old friends at Harvard, students and faculty alike. Especially EPS Professor Emeritus Charlie Burnham and the late faculty member Jim Thompson (1921–2011), who did so much

for me and many others. Now that Linda and I have actual, sentient ducks, I’m repeatedly reminded of Thompson’s mnemonic for octahedral skew in crystal structures, especially chain and sheet silicates:

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Octahedron (Duck) Orientation

(+ + - -) with enstatite and anthophyllite. Clinohumblonophsite, clinopyroxenes, and clinoamphiboles are all (+), or, if you view the ducks from their rear ends, (-), i.e., all the ducks swim in the same direction. (And yes, I’m the one who discovered and named the minerals clinohumblonophsite and clinojimthompsonite.)
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For those who love chain silicates, the mineral jimthompsonite shares the stacking sequence (+ + - -) with enstatite and anthophyllite. Clinohumblonophsite, clinopyroxenes, and clinoamphiboles are all (+), or, if you view the ducks from their rear ends, (-), i.e., all the ducks swim in the same direction. (And yes, I’m the one who discovered and named the minerals clinohumblonophsite and clinojimthompsonite.)

Scott Meddaugh PhD ’83, scott.meddaugh@mwsu.edu: I am currently the R.L. Bolin Distinguished Professor of Petroleum Geology at Midwestern State University in Wichita Falls, TX. I joined MWSU after retiring from Chevron. During my 32-year career at Chevron, I worked on a variety of projects as a research geologist and eventually as a project/technical manager for a large project in the Middle East. While at Chevron, I had the opportunity to work on reservoir characterization (geostatistics-based) and development projects worldwide including several of the world’s largest oil and gas reservoirs. Though based largely in Houston, my work involved projects throughout the world, and I managed to accumulate more than a million air miles on five different airlines. I remain active in the Society of Petroleum Engineers (SPE), the American Association of Petroleum Geologists (AAPG), and the European Association of Geologists and Engineers (EAGE). I have been a distinguished lecturer for the SPE (2016–17), and I have been an associate editor for the SPE Reservoir Evaluation & Engineering Journal for the past eight years. In addition to teaching and research, my major activities include running marathons (two or three per year). My wife, Janet, and I celebrated the birth of three grandchildren in the past year including a set of twins born in early February 2018.

My current research is focused on reservoir characterization and description of oil and gas reservoirs, fluid and gas production forecasting accuracy for oil and gas reservoirs, and reactive transport modeling (RTM).

Alan S. Kornacki PhD ’84, alan_kornacki@earthlink.net: I have been working as a consultant for Weatherford Laboratories in Houston since I retired from Royal Dutch Shell in 2010. I integrate petroleum geochemistry and petroleum engineering data to help oil and gas companies develop and manage shale reservoirs more effectively. For example, oil fingerprinting results demonstrate that oil commonly is produced from a smaller volume of shale than the amount stimulated by hydraulic fractures. I’m putting to good use the hard-earned familiarity with phase diagrams that I acquired in JBT’s graduate-level courses—albeit in a much different system than the composition of New England’s metamorphic rocks!

Jeffrey Love PhD ’93, jeffreyllove137@gmail.com: I am a research geophysicist within the Geomagnetism Program of the USGS. My research has, over the years, covered a variety of subjects related to the Earth’s magnetic field. These days, I concentrate on using geomagnetic monitoring data and magnetotelluric survey data to evaluate geoelectric hazards that are a concern to the electric-power grid industry.

Bernhard Steinberger PhD ’96, bstein@gfz-potsdam.de: Since 2009, I have been a senior researcher at GeoForschungsZentrum Potsdam (the German Research Centre for Geosciences, in Potsdam, Germany) and a professor II at the University of Oslo.
IN MEMORIAM

Philip H. Osberg  PhD '52, professor of geology at the University of Maine in Orono from 1957 to 1990, passed away September 30, 2016, at the age of 91. A World War II Navy veteran, he was an avid skier, and during the summers he worked for the Geological Survey in New England. He also helped edit the Bedrock Geological Map of Maine (1985) and published books, articles, and geological maps, gleaned from his field trips in Maine and New England. He made a contribution to plate tectonic shift theory and was a Fulbright scholar in Oslo, Norway, with later sabbaticals at Oxford, UK, and with the Geological Survey in Virginia.

Ursula (Bailey) Marvin  AM '46 (Radcliffe), PhD '69, renowned planetary geologist and author, passed away February 12, 2018, at the age of 96. Specializing in mineralogy, she worked with her husband, Thomas C. Marvin '39, for Union Carbide Corporation in Brazil, Angola, and the US in the 1950s. Back in Cambridge, she took a position at Harvard researching the mineralogy of meteorites, and in 1961 she was appointed to the permanent research staff of the Smithsonian Astrophysical Observatory (she retired in 1998). She studied samples gathered during the Apollo and Russian Luna missions to the Moon and traveled to Antarctica to collect meteorite samples. According to a February 19, 2018, Boston Globe article, she was the first female member of Harvard's geology club.

John W. Creasy  PhD '74, specialist of igneous rocks of the White Mountains of New Hampshire, including the celebrated ring dikes, passed away unexpectedly June 21, 2017. After earning his PhD (with noted Harvard structural geologist Marland Billings '23, PhD '27 [1902–1996]), Creasy joined the geology department at Bates College where as chair he reengineered the department into a state-of-the-art operation, widely admired for the quality of undergraduate education and particularly the research opportunities provided to students at that point in their careers. He retired in 2014 but remained active in his field.

Norway. My research aims at a better understanding of processes in the Earth's interior through numerical modeling with different observation data, in particular from seismology, geodesy, and mineral physics as boundary conditions. In particular, I investigate the relation of mantle convection and plate tectonics, the role of mantle plumes and their influence on the lithosphere, and the contribution of true polar wander to surface motion.

In the years between my PhD and current positions, I worked as a postdoctoral researcher at Academia Sinica, in Taipei, Taiwan (1996–1997), and at Frankfurt University, Germany (1997–2001). I then was a visiting researcher at the University of Colorado, Boulder (2001–2002), and at Bayerisches Geoinstitut, in Bayreuth, Germany (2002 and 2004). I also worked as a researcher at IFREE, JAMSTEC, in Yokosuka, Japan (2004), and at the Geological Survey of Norway, in Trondheim, Norway (2004–2009).

Jonathan Payne PhD '05, jonpayne14@ gmail.com: I continue to teach in the Department of Geological Sciences at Stanford, where I have been since 2005. My wife (Ellen Chang, Harvard College '98, School of Public Health ScD '03) and I are kept quite busy by our children, Oliver (10) and Tessa (6), who have been building a collection of rocks and fossils from our trips to various national parks and volcanoes.

Diana Valencia PhD '08, valencia@astro. utoronto.ca: I’m an assistant professor at the University of Toronto, Scarborough.

Victor Tsai PhD '09, vtsai@post.harvard. edu: In May 2017, I was promoted to professor of geophysics at Caltech, where I have been since 2011. Not much has changed though: I’m still enjoying sunny Southern California as well as the many collaborations I have here at Caltech and elsewhere.

Itay Halevy PhD '10, itay.halevy@weizmann. ac.il: Since 2011, I have been assistant professor in the Department of Earth and Planetary Sciences at the Weizmann Institute of Science in Rehovot, Israel.

Karen Aline McKinnon '10, MA '14, PhD '15, karen.mckinnon@post.harvard. edu: After finishing my PhD, I headed back west to Boulder, CO, to do a postdoc at the National Center for Atmospheric Research where I was working on merging model-data insights about internal climate variability. In September 2017, I moved to Santa Fe, NM, to start a job as an applied scientist at Descartes Labs. My work is oriented around building models using weather and remote sensing data, ranging from crop yield forecasting to monitoring of global surface water. Updates, papers, and such are on my website: https://karenamckinnon.github.io/.

Undergraduates

Frederic Siegel  '54, ffrmsiegel@msn. com: At Harvard I had classes with Kirtley F. Mather, Cornelius Hurlbut, Marlon P. Billings, Hugh McKinstry, and other giants of that era. It was Professor Billings who got me my first job as junior assistant geologist with the then Newfoundland Geological Survey as member of a field party working in central Labrador during the 1953 summer. Professor Mather suggested that I do graduate work at the University of Kansas where a Denison classmate of his, Raymond C. Moore, another giant of that time, directed the program. After graduation I entered the Army (served in the ETO in Germany and France); once out of the Army in 1956, I went to KU for an MS (1958) and PhD (1961) in geology with a chemistry minor.

After completing a PhD with a dissertation on the origin of primary dolomite and dolomite ther- moluminescence, I accepted a position at the Miguel Lillo Institute in Tucuman, Argentina. In 1963 I took the position as head of the Geochemistry Division of the Kansas Geological Survey and also taught at KU. In 1965 I moved to George Washington University as the geochemistry professor; I remained there until I retired at the end of 1999.

I served as department chair from 1976 to 1986 and developed a hydrogeology program with expert lecturers from the USGS and Smithsonian Institution. I was fortunate to be a mentor or co-mentor to 16 PhD and 29 MS recipients. During my career and in retirement, I published many journal papers and I am up to seven books. I am now completing Cities and Mega-Cities Today and in the Future. It deals with land-use planning in the rehabilitation (redevelopment) of major cities.
Boston Latin School prepared me for Harvard. My Harvard education provided me with a broad educational experience together with my geology major, while the University of Kansas graduate geology program filled in and extended my geological science and chemistry base. These led to a fulfilling career.

Lincoln Hollister ’60/’61, linc@princeton.edu: My family and I really enjoyed the Harvard Museums of Science & Culture (HMSC) trip to see the total eclipse in Wyoming and to explore the geology of the Grand Tetons and Yosemite, led by EPS associate Mark Van Baalen in August 2017. We hope to join Mark for his next eclipse trip, in June 2019 to Chile.

Andrew Strasfogel ’67, astrasfogel@gmail.com: I am currently a senior analyst–land use planning for the US Bureau of Land Management, based in Washington, DC.

Susan Comstock ’78, susan.l.comstock@gmail.com: I retired from my first job out of college two years ago—commercial banking

NEXT STEPS: 2016–17 PhD GRADUATES

Twelve EPS graduate students received their doctorate in academic year 2016–2017. With dissertations electronically bound (available at http://dash.harvard.edu) and PhD diplomas in hand, our most recent alumni have dispersed around the globe.

PHOEBE ROBINSON DEVRIES
DISSERTATION: “Unified Viscoelastic Models of Earthquake Cycles”
ADVISOR: Brendan Meade
CURRENT POSITION: Postdoctoral fellow, EPS
IN 2019: Assistant faculty, University of Connecticut

ATHENA EYSTER
DISSERTATION: “Paleomagnetic and Geochronologic Constraints on the Neoproterozoic Tectonics and Climate of the Western Margin of Laurentia”
ADVISOR: Francis Macdonald
CURRENT POSITION: Crosby Postdoctoral Fellow, MIT

CLAIRE HEALY
DISSERTATION: “Mapping and Characterizing the Alaskan North Slope Methane Flux with Airborne Eddy-Covariance Flux Measurements”
ADVISOR: Jim Anderson
CURRENT POSITION: Engineer, Creare Inc.

HANNnah Horowitz
ADVISOR: Daniel Jacob
CURRENT POSITION: NSF postdoctoral research fellow, University of Washington

SARAH HURLEY
DISSERTATION: “Molecular and Isotopic Investigations into the Ecology of Marine Thaumarchaeota”
ADVISOR: Ann Pearson
CURRENT POSITION: Postdoctoral fellow, University of Colorado, Boulder

SHANNON KOPPLITZ
DISSERTATION: “Air Quality in Southeast Asia: The Growing Threat of Coal Emissions and Land Use Change Fires to Human Health in a Rapidly Evolving Region”
ADVISORS: Daniel Jacob and Loretta Mickley
CURRENT POSITION: Postdoctoral physical scientist, US Environmental Protection Agency

HARRIET LAU
DISSERTATION: “Large-Scale Mantle Structure Observed Through the Lens of Geodynamical Processes”
ADVISOR: Jerry Mitrovica
CURRENT POSITION: Postdoctoral fellow, EPS; Junior Society of Fellows, Harvard University

DING MA
DISSERTATION: “Investigations of Three Dominant Patterns of Large-Scale Circulation Variability in the Atmosphere”
ADVISOR: Zhiming Kuang
CURRENT POSITION: Postdoctoral fellow, Columbia University

ANDREW MASTERSON
DISSERTATION: “Multiple Sulfur Isotope Applications in Diagenetic Models and Geochemical Proxy Records”
ADVISOR: David Johnston
CURRENT POSITION: Senior research associate, Northwestern University

CHRIS MILLER
ADVISOR: Daniel Jacob
CURRENT POSITION, Postdoctoral fellow, Harvard-Smithsonian Center for Astrophysics

CRISTIAN PROISTOESCU
DISSERTATION: “On the Time Scale Structure of Climate Variability and Response”
ADVISOR: Peter Huybers
CURRENT POSITION, Postdoctoral research associate, University of Washington

JONATHAN TUCKER
DISSERTATION: “A Portrait of Terrestrial Volatile Evolution from Mantle Noble Gases”
ADVISOR: Sujay Mukhopadhyay
CURRENT POSITION. Postdoctoral fellow, Carnegie Institution for Science

Sarah MacVicar ’13 wearing her EPS cap during one of her many adventures in northern BC.

Lincoln Hollister ’60/’61 with his wife, Sarah, in Wyoming to see the eclipse last summer.

PHOTO CREDITS: Buzz Mason

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with what eventually became JPMorgan Chase—and am now involved in a number of nonprofits and am loving it. The kids are scattered, and my husband and I are splitting time between Chicago and Tucson. I’m enjoying throwing around terms like basin and range, igneous intrusion, etc. Who knows if I’m right, but I’m finding it very easy to impress the average acquaintance. If you find yourself near me, please get in touch.

Jane Satter ’78, jane.satter@gmail.com: I have fond memories of my geology days, in particular studying roadcuts around the Boston area. My geology background has provided a source of entertainment to family and friends as I have traveled around the country and internationally. I have been fortunate to have a rewarding career as a family physician outside of Durham, NC. If any readers are interested in learning more about the transition from geology to med school, please feel free to contact me.

Karen Knuuti ’85, Karen.Knuuti@maine.gov: I work for the Maine Department of Environmental Protection, Bureau of Remediation and Waste Management, where I’ve been for about 30 years, mostly working with solid waste facilities. The state allowed me to take classes at the University of Maine, so I’ve studied more geology, hydrogeology, and soil mechanics. Although I don’t work as a geologist, I belong to the Geological Society of Maine, occasionally go on the society’s field trips, and always have an eye out for geologic features, including a spectacular rock cut I pass by every day on my way to/from work. I live in the midcoast area and like to be outdoors, although I curse the spreading geologic features, including a spectacular rock cut I pass by every day on my way to/from work. I live in the midcoast area and like to be outdoors, although I curse the spreading range of the deer tick.

Chris Leggett ’93, chris.leggett@rsgrnc.com: I currently work at Resource Systems Group in White River Junction, VT (www.rsgrnc.com). I work on studies related to outdoor recreation on public lands.

Mark Potosnak ’94, mark@potosnak.net: I was recently elected as department chair for Environmental Science and Studies at DePaul University where I teach climate change and Earth system science—and often regale students with stories of how I first learned about global warming and the ozone hole as an undergraduate EPS major in the early 1990s. I also continue to study plant-atmosphere interactions and urban air quality.

Kalon Morris ’98/’99, kmorris@post.harvard.edu: I just finished my second sabbatical project (travels included White Sands, Carlsbad Caverns, and El Malpais, in New Mexico, and Sunset Crater, in Arizona) and have now returned to my 16-year career of teaching oceanography, meteorology, and geology at Saddleback College in Southern California. And I’ve gotten into the new sport of wakefoiling! Follow me on Instagram: @captainkalon.

EPS associate Mark Van Baalen (right) celebrating the successful dissertation defense of former advisee Tom Benson ’09 at Stanford University in May 2017. Tom’s PhD dissertation was titled “Geology, 40Ar/39Ar Geochronology, and Lithium Enrichment of the Mid-Miocene McDermitt Volcanic Field (Nevada and Oregon, United States).”

Tom Benson ’09, thomasrbenson@gmail.com: I completed my PhD in geological sciences at Stanford University in May 2017, and I am currently the lead global exploration geologist for Lithium Americas Corporation, based in New York City. I am also a research associate at the American Museum of Natural History. Last summer, my research was published in Nature Communications and was featured in a discussion about lithium deposits hosted in supervolcanoes on NPR’s Science Friday. For more information, please see my website: www.tombenson.rocks.

Ben Miller ’10, bimiller@post.harvard.edu: I’m currently working for the Commonwealth of Massachusetts—in the Executive Office of Energy & Environmental Affairs—as staff on the Global Warming Solutions Act.

Jimmy Looney ’14, jlooney6@gmail.com: I’m now in my fourth year of teaching computer science to juniors and seniors at Westwood High School (Westwood, MA). I will be bringing the world of EPS to the high schools this June by teaching a five-day workshop called “Weather and Geology of New England.” I’m really looking forward to delving back into the Earth science field! I also spent a week this past December visiting family (and fishing, snorkeling, and relaxing) in the Marshall Islands.

Valerie Shen ’14, i.am.valerieshen@gmail.com: I am currently a first-year student at Stanford’s Graduate School of Business, pursuing a joint MBA and master’s in environment and resources. It’s been great being back at school again and meeting fantastic people from all over the world. Prior to business school, I helped launch G2VP, a venture capital fund, investing in teams applying emerging technologies to traditional industries, sustainably. I also completed my goal of traveling to all 50 US states, and hiked in all nine of California’s national parks!

Katherine Marie Kulik ’15, katherinekulik4@gmail.com: Since graduating, I have been working at Alphataraxia Management, a fast-growing energy investment firm in Arlington, VA (alphataraxia.com). I have also been involved with the Environmental Data and Governance Initiative (envirodatagov.org), completing an analysis of the EPA and continued monitoring of at-risk environmental data and websites. In my spare time, I love exploring the DC restaurant scene, hosting trivia gatherings (especially when they ask any geology-related questions), and skiing!

Cecilia Sanders ’16, csandersstop@gmail.com: Hi, friends! I’m currently hurling toward the end of my second year pursuing a PhD at the California Institute of Technology. Keeping my feet grounded in the planetary science option (finding motivation in the search for life beyond Earth), but keeping my head and my heart over in geobiology, has served me well. I’m currently working on a few projects: Trying to cultivate chemotrophic microbes and characterize their associated biosignatures under conditions relevant to the continental subsurface of Earth and Mars. Trying to look for evidence of chemotrophic...
microbes preserved in the fracture-fills of ancient basalts. Trying to map and develop a paleoenvironmental story for Ediacaran-age phosphorites in Bahia, Brazil, in advance of cracking them open and looking for micro-fossils. Trying to pile on field experience in Namibia (where I’ll be this summer, with our own Judy Pu G2 and Lyle Nelson ’15!).

In addition to research, I’ve been teaching science once a week at a local public elementary school. The other volunteers and I develop and execute lesson plans and hands-on activities for K–5. It is a joy to work with these children, and truly an education to figure out how to explain wave physics, the history of the solar system, material science, and more to the small and intellectually ravenous.

It was wonderful to spend time in the Caribbean last summer having an Agouron Field Experience with our own Andy Knoll, and I am absolutely PUMPED to do it again in Namibia and Brazil with dear Harvard EPS friends.

From left to right: Tyler Cusick ’14 (EPS secondary, social studies primary), Katie Sierks ’13 (EPS secondary and environmental engineering primary), and Alex Morgan ’14 (joint EPS-engineering sciences) reunited at this year’s Harvard-Yale game in New Haven (disappointingly, Harvard lost 24–3). Tyler is a marketer at Google in California; Katie is pursuing an MBA/master’s of environmental science at Yale (perhaps the score wasn’t so disappointing for Katie?); and Alex is a wind energy analyst at Bloomberg New Energy in New York.

NEAL CHAMPAGNE: Neal is a man of mystery.

KAITLYN GIBSON: Since July 2017, I have been on a two-year working holiday in Australia, New Zealand, and Japan. I have been involved in a number of jobs, including collecting fossils with Andrew Knoll’s group and driving tractors. Currently, I am about to begin a job as a junior geotechnician with a gold mining company in Darwin, Australia, and in June I will go to New Zealand to coach ski racing. I’m sampling everything that this side of the world has to offer!

RACHEL HAMPTON: In fall 2017 I began pursuing my PhD in volcanology at the University of Oregon. I will be studying magmatic systems through isotope geochemistry and modeling of magma transport in the crust with Professors Ilya Bindeman and Leif Karlstrom. I couldn’t be more excited to continue studying the earth around me and in particular studying volcanoes in the heart of the Cascades.

CAROLINE JUANG: I completed a summer internship as a business development intern with Bryce Space and Technology and as an inaugural member of the Brooke Owens Fellowship Program. Starting in September, I began my job as a landslide citizen science project coordinator at NASA Goddard Spaceflight Center. I’m about to launch our project, Landslide Reporter, which will invite the public to contribute landslide events to a global landslide database. I’m learning a lot about citizen science and natural hazards!

LEORE LAVIN: I’m working as an energy consulting associate for PowerAdvocate, an energy consulting and tech company in Boston. We work with and travel to electric utilities and oil and gas companies to help them with strategy and supply chain management. I’m loving it and Central Square.

FORREST LEWIS: I will be living in Banjul, Gambia, for a year on a Michael C. Rockefeller Traveling Fellowship working in a school and exploring aspects of West African culture.

MATTHEW LUONGO: After graduating in May 2017, I went on a two-month road trip across the US and visited 17 national parks. Most recently, I’ve moved to Brooklyn, NY, where I have been working as an energy and utilities consultant with West Monroe Partners. Specifically, I’ve been working with utility companies to help plan and implement large-scale sustainability and grid modernization projects and initiatives.

MICKEY MACKIE: I’m starting a PhD in geophysics at Stanford, working in Dustin Schroeder’s radio glaciology group on radar analysis and glacial modeling. My research is on Antarctic subglacial lakes and the Thwaites glacier paleoenvironment.

MATTIE NEWMAN: I currently live in Midland, TX, and have worked for Chevron since November 15, 2017. My current position is as an environmental specialist–air in the HES (Health, Environment, and Safety) Department. My role includes supporting facilities with any air-related needs such as federal and state permitting and compliance. Particularly, I will be supporting Chevron’s growth regions in compliance, and I support the company’s base, existing operations, with both permitting and compliance. Overall, my role helps to ensure Chevron’s environmental compliance and management of emissions. This will be my first of many rotations with Chevron.

WOOJIN PARK: I officially started my job as a consultant for Novantas as of fall 2017. So far, I’ve been involved in various projects with Bulge Bracket Banks to help them adapt to the current rising fed rate environment.

ABIGAIL PARKER: Last fall, I started a PhD in vertebrate paleontology at the University of Cambridge (working with Jason Head in the zoology department). I am studying the evolution of body size in Cenozoic reptiles.

NEAL CHAMPAGNE: Neal is a man of mystery.

KAITLYN GIBSON: Since July 2017, I have been on a two-year working holiday in Australia, New Zealand, and Japan. I have been involved in a number of jobs, including collecting fossils with Andrew Knoll’s group and driving tractors. Currently, I am about to begin a job as a junior geotechnician with a gold mining company in Darwin, Australia, and in June I will go to New Zealand to coach ski racing. I’m sampling everything that this side of the world has to offer!

RACHEL HAMPTON: In fall 2017 I began pursuing my PhD in volcanology at the University of Oregon. I will be studying magmatic systems through isotope geochemistry and modeling of magma transport in the crust with Professors Ilya Bindeman and Leif Karlstrom. I couldn’t be more excited to continue studying the earth around me and in particular studying volcanoes in the heart of the Cascades.

CAROLINE JUANG: I completed a summer internship as a business development intern with Bryce Space and Technology and as an inaugural member of the Brooke Owens Fellowship Program. Starting in September, I began my job as a landslide citizen science project coordinator at NASA Goddard Spaceflight Center. I’m about to launch our project, Landslide Reporter, which will invite the public to contribute landslide events to a global landslide database. I’m learning a lot about citizen science and natural hazards!

LEORE LAVIN: I’m working as an energy consulting associate for PowerAdvocate, an energy consulting and tech company in Boston. We work with and travel to electric utilities and oil and gas companies to help them with strategy and supply chain management. I’m loving it and Central Square.

FORREST LEWIS: I will be living in Banjul, Gambia, for a year on a Michael C. Rockefeller Traveling Fellowship working in a school and exploring aspects of West African culture.

MATTHEW LUONGO: After graduating in May 2017, I went on a two-month road trip across the US and visited 17 national parks. Most recently, I’ve moved to Brooklyn, NY, where I have been working as an energy and utilities consultant with West Monroe Partners. Specifically, I’ve been working with utility companies to help plan and implement large-scale sustainability and grid modernization projects and initiatives.

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I Remember WHEN

Talent Shows in the Early ’70s

BY ROBERT KAMILLI PHD ’76

In the early 1970s students and faculty in the geology department participated in annual talent shows held on a convenient Friday afternoon in the lounge on the fourth floor of Hoffman Labs. Most of the performances were musical, but others included juggling, Monty Python skits, skits parodying faculty, and even some electronic music.

A perennial highlight was the late Steve Gould (Stephen Jay Gould, 1941–2002, then a professor in the department), who had a predilection for Elizabethan and late-17th-century ballads and rounds, with a twist: the singers (Steve and graduate students who could sing a cappella, such as Andy Knoll PhD ’77, now Fisher Professor of Natural History and professor of Earth and planetary sciences) would begin at different points in the round, and when the parts were juxtaposed just so, the song would take on a risqué meaning.

The show often concluded in a musical jam, with the likes of Bob Kamilli PhD ’76 on banjo, Eric Sundquist PhD ’79 on trumpet, Steve Richardson PhD ’75 on guitar, and Jack Sepkoski PhD ’77 on washtub bass. The performances were well lubricated with beer, wine, and popcorn.

These shows would generally end with all the graduate students gathering at someone’s apartment, with a few people assigned to buy food for the group, generally spaghetti. Cooking and testing the spaghetti for doneness was as much fun as the eating.

The department was quite musical in those days. For a few years, the third floor of Hoffman Labs hosted the following instruments (and the people who could play them): two banjos, two flutes, three guitars, one trumpet, one piccolo trumpet, and one cello; a German shepherd acted as a guard dog. The faculty were quite tolerant of all the practicing, mainly because the musicians were all pretty good.

Those were the days.

Bob Kamilli can be reached at bkamilli@comcast.net.

100TH

We mistakenly noted in the last issue of Earth & Planetary Times that the GeoClub would be celebrating its 100th anniversary in 2018. In fact, the first meeting was in January 1919, so 2019 will mark the club’s 100th year. The upside to this miscalculation is that it provides us with more time to plan a reunion of sorts; more information to come.

The department’s musicality was evident during the 1970s’ talent shows, which often featured folk songs from the ’60s and ’70s, Bob Dylan songs (for example, “Don’t Think Twice”) and Peter, Paul and Mary’s “Bamboo,” and original compositions. Here, Mike Mottl PhD ’76 and Carmen Apelgren sing a duet; Malcolm Siegel PhD ’81 plays acoustic guitar; and Tim Grove PhD ’76 serves as page turner while Bob Hazen ’75 plays the trumpet.
Meet five of the EPS community’s newest members wearing the (exclusive) EPS baseball cap. Left to right, Alexandre, 1 year (Marine Denolle and Brad Lipovsky); Adrienne, 9 months (Esther and Donnelle James), Zoe Jack, 2.5 years (Francis Macdonald and Kelsey Jack); Alejandro, 17 months (Danielle and Esteban da Cruz); and Macsen, 3.5 years (Robin Wordsworth and Seirian Lewis).

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 students, alumni, and friends donning EPS-embellished clothing, please visit our website: http://eps.harvard.edu/campus-and-beyond.

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EPS Baseball Cap Order Form

Relaxed twill, adjustable strap in back makes one size fits all.

Please make your check payable to Harvard University, with a note indicating that it is for the EPS baseball cap. Each cap costs $15.

I am enclosing a check for $ ___________ to pay for ____ (number of) cap(s).

My email:_________________________________________  My daytime phone:____________________________________________

Please mail this order form and check to:
Department of Earth and Planetary Sciences
Harvard University
Hoffman Labs, Attn: Kathleen McCloskey
20 Oxford Street
Cambridge, MA 02138
Please Consider Giving to EPS

EPS strives to provide unique and challenging fieldwork and research opportunities to our students, both undergraduate and graduate. The generosity of our extended community directly contributes to making these opportunities possible, and we are extremely grateful for such expressions of support. 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
Harvard University
Attention: Kathleen McCloskey
20 Oxford Street
Cambridge, MA 02138

Tidings

EPS is always pleased to hear from our alumni and friends. Please send your comments or news to us at 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 this note, my email address and/or web-link, and any associated photo, which may or may not appear in print and electronic versions.” Notes may be edited to fit the available space.

Editor’s note: Due to a last-minute design change, the colors of the lines in the legend accompanying the Gravitas graph in last year’s Earth & Planetary Times were mistakenly reversed: The orange line should have been density; the blue line, gravitational acceleration. We apologize for this error and thank the keen eye of Paul Asimow ’91; J. William Munger, senior research fellow, SEAS; Priestley Toulin ’51, PhD ’59; and Ellis Parker Walker ’92, who caught this mistake and brought it to our attention.