Welcome to our annual update. This is an opportunity to reflect on the past year and to showcase the exciting science within EPS. We begin with a celebration of 30 years of cross-disciplinary discovery at the Center for Isotope Geochemistry (page 3). Fundamental research is being done at all levels, in line with the new campus strategic plan to make discovery a focal point of the Berkeley experience, we advance research opportunities for undergraduates, such as department citationist Maryn Sanders (page 14), Valedictorian Cy David (page 15) and Association of Women Geoscientists Awardee Fran Meyer (page 18). We also welcomed two new adjunct professors, Benjamin Gilbert and Kanani Lee. Our faculty, students, staff and alumni continue to make our department one of the world’s best. Accolades continue to pour in, and I highlight a few: Daniel Stolper (page 8) was selected as a Sloan Fellow in Ocean Sciences and was presented with the Clarke Award from the Geochemical Society for outstanding contributions to geochemistry. Postdocs Alex Turner and Sarah Arveson received named early career awards from AGU. The more senior members of the department are doing OK as well, with Roland Burgmann and Michael Manga being elected fellows of the American Association for the Advancement of Science. Continuing a department tradition of striving for excellence in teaching, Nick Swanson-Hysell was awarded the Noyce Prize for Excellence in Undergraduate Teaching (page 12). These are challenging times for the Earth Sciences as we face rollbacks of environmental protections and the denial of scientific data and the facts we uncover through our research. Yet the geosciences remain as important as ever, from identifying new resources (page 10) to mitigating natural hazards (page 11). And the new fundamental discoveries enabled by space exploration (page 6), the ability to model climate systems (page 7), and making new and precise geochemical measurements (pages 3 and 8) remind us how much more there is for us in EPS to learn and contribute. Our department has a mission statement: research, education and service in EPS is driven by a fundamental human curiosity about the past, present and future of Earth and other planets. We underpin our intellectual mission with a comprehensive dedication to equity, accessibility and inclusion for all. As the rise of nationalism creates new barriers to supporting international students and collaborations we were pleased to grant the first Houtzager award to Michelle Devoe (page 19) to support field research in developing nations. Our department’s legacy is the success of our alumni. So please keep us informed and share your advice. Our collective achievements are not possible without your continued involvement and help. In closing, I highlight the remarkable resilience of our students, staff, postdocs, researchers and faculty over this past year. The teaching evaluations this past spring were the best we have ever seen. While the challenges and tragedies are too many to recount, this report shares some of our successes and visions.

CONNECT WITH US
Please keep us updated and share a sentence or two for next year’s annual update at eps.berkeley.edu. Our department’s legacy is the success of our alumni. Feel encouraged to share your suggestions and recommendations. Alumni can request to join our LinkedIn group; please find the group here: https://www.linkedin.com/groups/6927573. The costs of field experiences remain a barrier to providing an inclusive education. We remain committed to providing the best field education we can to all students. Our collective achievements are not possible without your continued involvement and help.

Photo: Headining up Ulama volcanoes, Chile, in January 2020 to sample the CuraccaVolcanic. Photo by Michael Manga.

Cover Photo: Students in Prof. Swanson-Hysell’s EPS 39 “Earth Science in the Field” freshman seminar course make observations of the Santa Cruz Mudstone at Shark Fin Cove. Photo credit: Nicholas Swanson-Hysell.

FROM THE CHAIR
The Center for Isotope Geochemistry was built in what is now McCone Hall in 1988 through 1989, just as I was moving to Berkeley from UCLA. At the time, the department was called Geology and Geophysics, and the building was “Geology.” The labs built on the 4th floor were the first major renovation project in the Geology building since its completion in 1960. The laboratory was first fully operational in 1990, so this year (2020) marks the 30th anniversary. The idea that early career faculty at major research universities would need extensive start-up support from both the University and NSF first started to take hold in the 1980s. NSF Earth Sciences did not yet have an Instrumentation and Facilities program. Electro-microprobes were the only relatively expensive pieces of analytical equipment that were regularly funded. In 1979 I received $180k from NSF at UCLA to purchase a new thermal ionization mass spectrometer (TIMS) and this was the first time NSF had ever provided funding for a mass spectrometer. Universities did not provide “startup” packages, or if they did, they were tiny by today’s standards. By 1988, partly as a result of the new excitement that had been generated by studies of Nd isotopes, it had already become more commonplace for NSF to partially fund mass spectrometers, and for universities to provide laboratory renovation and instrument matching funds for new faculty. Through the efforts of George Brimhall and Tom McEvilly, and because UC had implemented a new statewide program, Berkeley was able to offer the support needed to build a lab on campus, and start a new research program concurrently at what was then called “LBL.” So the Berkeley Center for Isotope Geochemistry (BCIG) came into being as a joint UC Berkeley – LBL effort in the 1988-1990 time period. Campus was well organized, and planning for the new labs started quickly. Construction started in 1988 and the labs were finished in early 1990 under budget! A significant issue was that the labs took up about 2000 square feet of space, and required fume hoods (there are 7 total), as well as an HVAC system that provided HEPA-filtered air and keep the temperature controlled. The space was obtained by using a large lecture/lab room on the fourth floor (think of room 365 and imagine the lab bench at the southeast corner of the building. These rooms were reconfigured into 5 rooms, the main ones being a clean chemistry lab, a mineral separation room, and a mass spectrometer lab. A large air handling unit was needed, so there is a separate room that houses the fan unit and is also used for other purposes. The fume hoods were another issue. The hoods need to vent to the roof through the building, so 7 separate risers needed to be built that would go up through the 5th floor to the roof. The Berkeley Seismographic Stations (as it was then known) occupied the 5th floor over the soon-to-be chemistry and mass spec labs. The inhabitants needed to weather several months of demolition and construction and loss of significant floor space.

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Continued on next page
At the time the lab was built it was one of the most modern and well-equipped clean chemistry and mass spectrometry labs in the world. There were two thermal ionization mass spectrometers (TIMS) and ample space for carrying out chemical separations from dissolved rocks and minerals. Tom Owens was in charge of the labs, and the first Berkeley graduate students who worked in it were Tom Johnson, John Lassiter, Ken Sims, and Sean McCauley, who were also joined by Eric Wendlandt and Ellen Daley who moved up to Berkeley from UCLA. Scott Borg was the first postdoc to use the lab, followed by Jo Lin, Chang-Hwa Chen, and Steve Getty.

Research in BCIG started with a focus mostly on igneous and metamorphic rock geochemistry with a second theme related to sedimentary provenance studies and Sr isotope stratiography and paleoceanography. These studies, which have continued to the present, produced fascinating results relating to extensional volcanism (Daley) and ignimbrites (Frank Perry) in the western U.S., layered intrusions (Brian Stewart) and flood basalts (Lassiter), melting rates in mantle plumes (Sims), deep crustal xenoliths from the Four Corners area (Wendlandt), active volcanoes (Cheni), Antarctic (Borg) and Himalayan (Cheni) granites, deformation rates in Alpine schists and gneisses (John Christensen), and new approaches to Quaternary geochronology (Getty) and Cenozoic stratigraphy (Rose Capo). Dan Schrag used the stable isotope facilities built at LBL and deep sea pore fluids to stratigraphy (Rose Capo). Dan Schrag used the stable isotopes to measure how fast deep-sea carbonates recrystallize during diagenesis (Matt Fanale). Kate Maher worked out new ways of measuring sediment transport times and vadose zone infiltration rates using U isotopes. Maureen Feineman worked with Nick Ryerson at Lawrence Livermore National Laboratory on experiments related to subduction zone processes, beginning a series of experimental studies that have continued to the present. Sarah Aiciego, working with Mack Kennedy at LBNL, showed that U-Th-Hf could be used to date volcanic rocks that are too old to date with radiocarbon and too young to date with Ar-Ar. Jim Watkins, also working with Ryerson, showed that isotopic fractionation caused by diffusion in silicate liquids could be used to probe silicate liquid structure and diffusion processes.

Highlights since 2010 include new models for how calcite incorporates isotopes and trace elements, and how that depends on growth rate and fluid chemistry (Laura Nielsen Lammers, Jim Watkins, Jenny Mills, and Liz Milnick), how Ca isotopes can help understand processes in the earliest stages of the solar system (Justin Simon), how fast CO2 can be turned into carbonate minerals during subsurface carbon sequestration (Shuo Zhang), and how uranium can be tracked in groundwater at sites that have been used for uranium solution mining (Anirban Basu and Shaun Brown). Michael Antonelli continued the high temperature geochemistry theme using Ca isotopes to characterize chemical transport processes in amphibolite and granite facies metamorphic rocks. Shaun Brown and Sasha Turchyn, followed later by Antonelli and Nick Pester, made the discovery that certain aspects of the chemistry of ancient seawater changed the chemical exchange between seawater and the ocean floor. Jenny Druhan was able to demonstrate how isotope fractionation can be incorporated into reactive transport models for groundwater, and Anna Clinger used U isotopes to measure how long it takes sediment to be transported from the Himalaya to the Bengal Fan.

In 30 years the BCIG labs have provided the focus for this large range of fundamental Earth science studies. In the meantime, isotope geochemistry has gone through extraordinary growth such that almost every element in the periodic table is now the subject of isotopic studies. Fancy new labs are found on 5 continents and new ones continue to be built. At Berkeley, there has also been a major expansion, in EPS, in related departments, and at the Berkeley Geochronology Center. We are proud to have contributed, and continue to contribute, to the excitement around isotope geochemistry, and to have helped to keep Berkeley in the middle of the conversation.
ALEX BRYK, GRADUATE STUDENT

I joined the NASA's Mars Science Laboratory (Curiosity Rover) team in January 2018, about 5 years after the rover landed in Gale Crater and began its journey of exploration for habitable environments. At this time, the rover had ascended Vera Rubin Ridge, a wind scoured, diagenetically altered outcrop of ancient lake sediments. Before us lay a shallow 500m wide trough that remote sensing indicated was rich in clay and thus may record an ancient habitable environment here at the foot of Mt. Sharp. Beyond the trough lay some isolated buttes, and then a several km long 10 m high escarpment cut by wind and preserving a remnant planation surface (pediment) that had developed at the foot of Mt. Sharp and likely once extended right across to where the rover was sitting. This was the first sighting of a pediment by a rover on Mars and it became a hope, shared with my advisor, Bill Dietrich, that the rover would have an opportunity to investigate it close up. At this distance, we could see that the pediment truncated the lake sediments and was probably overlain by a sandstone. Above the topographic plain rose a 70 m high ridge of sediment that had been interpreted to be a remnant of a once more extensive alluvial fan.

For the next year 1.5 years, I participated in planning and analysis that guided the rover beyond Vera Rubin Ridge across the clay-rich valley as we headed towards the pediment edge. Then in the past year, Bill Dietrich and I were given the opportunity to lead the rover to the landform now known as the Greenheugh pediment. We found the capping unit of the pediment to be lithified cross-bedded aeolian sandstone, and that it had undergone patchy diagenetic alteration. To our amazement, the mission determined we could ascend the pediment to be lithified cross-bedded aeolian sandstone, and that it had undergone the first sighting of a pediment by a rover on Mars and it became a hope, shared with my advisor, Bill Dietrich, that the rover would have an opportunity to investigate it close up. At this distance, we could see that the pediment truncated the lake sediments and was probably overlain by a sandstone. Above the topographic plain rose a 70 m high ridge of sediment that had been interpreted to be a remnant of a once more extensive alluvial fan.

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Curiosity has now traveled back down from atop the pediment in search of more organic compounds hosted in the sediments below the unconformity. Based on geologic mapping we did while crossing the clay-rich trough, we were able to predict and guide the rover to a specific stratigraphic zone where we are now drilling, demonstrating that core principles in geology are effective even when applied through a robot 225 million kilometers away from Earth!

ALEXANDER CHARN, PhD 2020

Microphysical processes involving water droplets and ice particles in the atmosphere are responsible for significant events such as extreme precipitation and lightning. However, as their name implies, they are difficult to observe in the real world and represent within weather and climate models. Regarding the latter, superparameterized climate models strike a balance between the cloud-resolving capability of high-resolution models and the computational efficiency of standard climate models, allowing a unique way to probe the effects of climate change on atmospheric processes where clouds and convection are important. While superparameterization has been shown to be superior to conventional approaches in simulating extreme rainfall, it is still unable to match the magnitude of observed extreme precipitation in many places. In a pair of studies, we show that, while the choice of microphysics leads to statistically significant differences in precipitation, particularly in the tropics, neither of two commonly used schemes is able to appreciably improve in this regard.

Lightning is generally considered to be the result of collisions involving ice particles, but most predictors of flash rates consist of correlations with larger-scale variables. We compare the performance of such a large-scale proxy with several ice-based quantities in a superparameterized model and find the latter to generally be superior in reproducing the observed global distribution of lightning. We also test the sensitivity of climate change-related predictions of lightning to the microphysics representation and find that the simpler scheme predicts decreases in many parts of the world, while the more complex one predicts more in the way of increases. In a final study we test the claim that lightning within clouds is dependent on precipitating ice particles by using satellite observations of cloud-top temperatures and three sets of lightning observations. The individual datasets yield a fraction of “warm-lightning” candidates smaller than their reported false alarm rates, so we attempt to find robust instances by cross-validating candidates across datasets. Because this effort results in zero matches, we deem there to be insufficient evidence to refute the hypothesis that lightning within clouds can occur in the absence of ice.
The presence of oxygen in the atmosphere (O2) fuels complex life, allows for combustion, leads to the oxidation of surface materials, and is inextricably tied to the activities of photosynthetic life. Although present at high levels in our atmosphere today (21%), this has not always been the case. For example, sometime between 800 million and 400 million years ago, oxygen is thought to have risen from ~1% of modern levels to the high levels seen today. This rise has been of longstanding geologic interest as it occurred at approximately the same time that animals, which require appreciable oxygen to live, evolved and diversified. As such the evolution of animals has for decades, to some controversy, been causally related to this rise in oxygen. So how do geochemists go about estimating when this change occurred? One approach has been to look to the oceans. Today, the deep ocean generally contains dissolved oxygen that was originally derived from the atmosphere. However, when oxygen levels were lower (~10-50% of modern), the deep ocean is predicted to have been devoid of oxygen. Thus if one could measure when the deep oceans became oxygenated, it would in turn help constrain when the atmosphere finally approached modern oxygen levels. In an ideal world, one could study ancient rocks formed in a deep ocean setting as a direct monitor of the deep ocean's geochemistry. Problematically, due to plate tectonics, most of these rocks have been subducted into the mantle. However, a small amount of deep-ocean-derived rocks are preserved in so-called ophiolites where oceanic crust is scraped off onto and preserved on continental crust. Many of you reading this will have visited such rocks during your time at UC Berkeley on departmental field trips to the Coast Range Ophiolite in Marin County — if you remember seeing pillow basalts as a student, you likely have seen an ophiolite. These pillow basalts bring us to the research part of this story. When I first arrived at UC Berkeley about 3 years ago, it became clear that my experimental geochemistry laboratory was going to take some time to build and I needed to find something to do with myself in my first year. An idea I had had relates back to those pillow basalts exposed in Marin and the history of atmospheric and oceanic oxygen levels. When pillow basalts erupt on the ocean floor, they are derived from magmatic melts that are relatively reduced compared to seawater. This can be seen by looking at their iron chemistry. Iron (Fe) today on the Earth’s surface exists largely as either Fe2+ or Fe3+. When oxygen reacts with reduced Fe2+, it makes oxidized Fe3+ (rust). Iron in freshly erupted pillow basalts is mostly reduced Fe2+ (~85%) — this is something that the late Prof. Ian Carmichael worked on extensively here at Berkeley. In the oceans, after pillow basalts erupt, seawater carrying dissolved oxygen flows through these basalts, reacting with them and oxidizing them. By the time this circulation finishes, much of the iron can be converted to oxidized Fe3+ (~20% in some places). So my idea was relatively simple: Compile measurements of Fe2+ vs Fe3+ values in pillow basalts preserved over geologic time (which exist back to ~3.5 billion years) and see if there are any obvious changes with time. A clear increase in oxidized Fe3+ would be indicative of the accumulation of oxygen in the deep ocean that then reacted with and oxidized these basalts. After a few months of digging through old papers, the data was compiled and it told an apparently coherent story. Pillow basalts suddenly became oxidized ~500 million years ago, indicating that not until this time did the oceans become largely oxygenated (Fig. 1). Given that animals evolved well before this time, this removes a causal link between the evolution of animals and the large-scale oxygenation of the ocean and atmosphere. Now why did this oxygenation occur when it did? This work does not answer that, but it provides constraints on plausible ideas. And as for my lab? I’m happy to report it was successfully built and became operational in early 2018, including the delivery of about 3000 pounds of mass spectrometers through the 4th floor balcony (Fig 2).
XIAOJING (RUBY) FU, POSTDOCTORAL SCHOLAR

New fluid mechanics insights to how methane gas migrate through deep marine sediments, feeding widespread methane vents in world ocean.

Methane represents a major contributor to atmospheric greenhouse warming, and is, per unit mass, about 50 to 100 times more potent than carbon dioxide. In determining the relative importance of methane to greenhouse warming, the biogeochemistry of the ocean and the global carbon budget, methane hydrates play a particularly important role. Methane hydrates — an ice-like solid substance made of methane and water molecules — are formed and commonly found in ocean sediments. While methane hydrates are stable over a range of depths that is hundreds of meters thick, widespread seafloor methane gas venting has been reported in many parts of the world ocean. Given the intuition that solid hydrate would likely clog the pore space within the sediment and prevent gas flow, how such gas migration pathways can be sustained over long periods of time is a long-standing puzzle (Figure 1).

In this study, we present evidence of a new phenomenon of solid-crusted gas percolation, which we term crustal fingering that, we believe, could be the key mechanism that explains the long-standing question of how free gas methane migrates through the hydrate stability zone in deep marine sediments around the world.

We address this question using controlled laboratory experiments developed in Los Alamos National Lab, as well as theory and simulations developed with colleagues at Technical University of Madrid, Swiss Federal Institute of Aquatic Science and Technology and Massachusetts Institute of Technology. We demonstrate that, contrary to intuition, the formation of hydrate does not always clog gas-flow pathways, but rather often facilitates the migration process (Figure 2). Further, complementing and contrasting the established theory that most marine hydrates on earth have formed out of dissolved methane, here we suggest that some subsurface hydrate fabric observed today could be a record of formation can, counterintuitively, facilitate rather than clog gas flow pathways.

This work provides a unifying theory that will allow the community to make progress on connecting the increasing amount of seafloor sonar data of methane venting dynamics with the seismic data on subsurface hydrate-derived plumbing structure to answer the question of where and how much methane is being released into the ocean through these naturally occurring methane seeps.

Below (Figure 1): Methane gas migration through shallow marine environment and the hydrate stability zone. Representation of a methane-rich gas reservoir (black) feeding the upward migration of methane gas through the seafloor sediments (grey) into the ocean-water column (blue), forming seafloor methane seeps (bubble plumes). The methane hydrate stability zone (HSZ) on earth is approximately 600m to 1400m below the ocean surface. Top two insets: two primary factors of gas migration in shallow sediments: (a) capillary invasion of gas to void at the sediment surface. Bottom inset: a reworking of methane gas migration within the HSZ proposed in this work: crustal fingering.

Figure 2: Experimental demonstration of crustal fingering process captured in a microfluidic device, demonstrating how hydrate crust formation can, counterintuitively, facilitate rather than clog gas flow pathways.
Berkeley's freshman and sophomore seminars provide an opportunity for students pursuing lower division coursework to get to know a faculty member in a small group and be introduced to new fields of study. Here in EPS, we have a tradition of teaching seminars that introduce students to Earth science in the field. It was in one such seminar that Prof. David Shuster (now an EPS faculty member) first became enthused about pursuing Earth science as his field of study. This year's Association for Women Geoscientists Outstanding Student Award winner Fran Meyer (Page 18) took such a seminar with Prof. Swanson-Hysell and subsequently became an EPS major. We are glad they both took the seminar to get started on their Earth science journeys!

In Fall 2019, Prof. Swanson-Hysell taught a seminar entitled "Earth Science along the California Coast." The focus of this seminar was to provide an opportunity for students to learn about the Earth through direct field observation. The central aspect of the course was a four-day field trip along the California coast. On the first day of the trip, the students visited classic exposures of the Marin Headlands terrane. With stunning views of the Golden Gate and dissipating fog, the students got their first experiences making observations of pillow basalt, radiolarian chert, and greywacke sandstone as well as thinking about these rocks in the context of California's tectonic history. After a night at Big Basin State Park, day two was spent on coastal outcrops in the vicinity of Santa Cruz observing Miocene and Pliocene sedimentary rocks. The fascinating injectite complex at Yellow Bank Creek led to stimulating discussion and there was excitement when students found marine vertebrate fossils at Capitola Beach. We stayed that night and the next in Carmel Valley at Hastings Natural History Reservation which is part of the UC Reserve system. A day at gorgeous Point Lobos gave us the opportunity to observe the guts of an ancient submarine canyon system that cut into Salinan Block granite. On day four, we crossed Salinas Valley and hiked through dramatic landforms composed of volcaniclastic breccia of the Pinnacles Volcanic Formation — a formation that famously journeyed northward from its sibling Neenach Volcanic formation in southern California on the other side of the San Andreas Fault. On our last stop in Hollister, students made observations and measurements on the active trace of the Calaveras Fault — a further reminder that tectonics are actively shaping California's landscape today.

Graduate student instructors were key to the success of the course. Danielle Lindsay, Claire Doody, Yiming Zhang as well as Postdoctoral scholar Maggie Avery all brought knowledge and enthusiasm that encouraged the students to make their own observations and connect the geological record to Earth processes. We are all looking forward to when we are through the pandemic and in-person field instruction can safely resume.
Maryn Sanders conducting fieldwork.

DEPARTMENTAL CITATION:

MARYN SANDERS

Hello! My name is Maryn and I received my bachelor’s degree in geophysics from the EPS department this May. I was awarded the departmental citation and am excited to share my work with department members and alumni. My love of Earth science began when I took earth science as a breadth class during my last year at community college, and I transferred to UC Berkeley the next year as a junior and intended geophysics major.

During my first semester in the department I took geomorphology, taught by Bill Dietrich. I learned about cross-disciplinary science of landscapes as Bill derived equations, showed the class photos of field sites, and led field trips. For the first time, I participated in the entire scientific process, from hypothesis generation to data collection to scientific writing. By the time I completed my end-of-semester project on rill formation, I was hooked on geomorphology.

In February 2019, I reached out to Mariel Nelson, Bill’s course reader (and EPS departmental advisor) to ask about potential research opportunities. Coincidentally, I asked right after a field site in Northern California was hit by dozens of shallow landslides—relatively thin landslides that involve only the soil layer but can become massive debris flows. Landslides also occurred at the site in 2017, but in different locations. I worked with Bill to understand the relationship between these two events through the Summer Undergraduate Research Fellowship program.

We compared the two landsliding events by analyzing landslide size, location, and the intensity of the storms that triggered them. To map the landslide locations, I used GIS software and aerial photographs of the field site to outline all 92 landslides that occurred in 2019. I then used detailed digital maps of the landscape (derived from airborne lidar) to extract topographic characteristics, like surface slope and drainage area, where landslides occurred. The 2019 landslides were the same size as 2017 landslides, but occurred at higher slopes and greater upslope drainage areas. Additionally, I ran a field campaign to measure 25 landslides and make observations of landslide processes that were impossible to see in the digital maps.

To look at rainfall patterns, I used data from rain gauges at the field site and a model made by researchers at Oregon State University to calculate cumulative rainfall and rainfall intensity. Rainfall can be highly variable from one hillslope to the next, so looking at multiple data sources allowed us to capture this variability. We compared our data to NOAA estimates of storm recurrence intervals from historical data, effectively telling us how rare the storms we recorded were. The 2017 and 2019 landslide triggering storms were almost identical in size and intensity; however, prior to the storm, 2019 was much dryer than 2017.

This year, I am happy to continue working with Bill as a staff member at the Eel River Critical Zone Observatory at Angelo Reserve, part of the UC Natural Reserve System. We plan to extract topographic characteristics, like surface slope and drainage area, where landslides occurred. The 2019 landslides were the same size as 2017 landslides, but occurred at higher slopes and greater upslope drainage areas. Additionally, I ran a field campaign to measure 25 landslides and make observations of landslide processes that were impossible to see in the digital maps.

By the time I completed my end-of-semester project on rill formation, I was hooked on the entire scientific process, from hypothesis generation to data collection to scientific writing. I could not be more appreciative of the EPS department, both for supporting me as an undergraduate and for recognizing my hard work this year. I am thrilled to have the opportunity to be affiliated with the department for another year and look forward to continuing research with Bill. Graduating during these intense times was emotional, but the department did a great job at providing spaces where we could celebrate our accomplishments and support each other online.

For me, this project was a fascinating application of fluid mechanics in an Earth science context, and an incredible research experience that taught me about theoretical development, scale modeling, data processing, and scientific writing. I am grateful to Dana Lapides, the Department of Earth and Planetary Science, and the Undergraduate Research Apprenticeship Program for giving me this opportunity and providing us with the resources and lab space.
This year EPS awarded 31 BAS, 1 MA, and 11 PhDs.

**Geology:** Abby Jackson-Gain, Fran Meyer and Erik Vides; not pictured: Aaron Tolpilo.

**Atmospheric Science:** Madeline Knauer and Anna Tarplin; not pictured: Rafael Castro.

**Geophysics:** Ariane Arndt, Lea Bartlett, Cj David, Jesca Gagliardi, Kevin Gao, Saeed Mohammadi and Maryn Sanders; not pictured: Kira Rodriguez.

**Marine Science:** Katrina Carter, Macenzie Davy, Laci Dobson, Chloe Luytens, Kaei Nguyen, Namaphat Simon, Camille Stepanof and Daisy Stock; not pictured: Alexandra Millston.

**Planetary Science:** Colin Dietmaier, Mohammat Mijum.

**Environmental Earth Science:** Edward Ramirez, Louis Walker and Miao Yulong; not pictured: Mariela Hernandez, Marco Perez.

**MA:** Ryan Carpenter.

**PhD:** Stephen Brenn, Alexander Charm, Isabel Fendley, Jenol Kim, Dana Lapiso, Nathaniel Lindley, Dallin Liu, Yuem Park and Chelsea Willett; not pictured: Nick Knezek, Prithvij.
Hi, my name is Fran Meyer and I graduated from the Earth and Planetary Science department this Spring. I am so fortunate to have been selected for the Association of Women Geoscientists Award, and am immensely grateful to the EPS department for helping me get to where I am today. I started my independent research with Nicholas Swanson-Hysell my sophomore year, and completed an honors thesis with this research project. I studied the paleoclimate of the Ordovician period by using existing oxygen isotope data from conodont elements, as well as collecting and analyzing new data. The Ramsden fund gave me the opportunity to go to Oklahoma and collect limestone samples for my own conodont element analysis. I also had the opportunity to go to UC Merced to conduct oxygen isotope analysis on my samples.

The Ordovician is a unique part of Earth history because it contains a major interval of biodiversification followed by a mass extinction that occurred at a time of global glaciation. It is well-established that the beginning of the Ordovician was characterized by a warm climate and the end of the period by a major glaciation, yet the trajectory of cooling through the period remains unclear. Because of this, it is still unknown to us what geologic mechanisms were driving ice sheet formation, and when cooling mechanisms originally began. With the help of many other researchers before me, I was able to produce a new oxygen isotope curve that communicates when cooling mechanisms originally began. With the help of many other researchers before me, I was able to produce a new oxygen isotope curve that communicates when cooling mechanisms originally began. With the help of many other researchers before me, I was able to produce a new oxygen isotope curve that communicates when cooling mechanisms originally began. With the help of many other researchers before me, I was able to produce a new oxygen isotope curve that communicates when cooling mechanisms originally began. With the help of many other researchers before me, I was able to produce a new oxygen isotope curve that communicates when cooling mechanisms originally began. With the help of many other researchers before me, I was able to produce a new oxygen isotope curve that communicates when cooling mechanisms originally began. With the help of many other researchers before me, I was able to produce a new oxygen isotope curve that communicates when cooling mechanisms originally began. With the help of many other researchers before me, I was able to produce a new oxygen isotope curve that communicates when cooling mechanisms originally began. With the help of many other researchers before me, I was able to produce a new oxygen isotope curve that communicates when cooling mechanisms originally began. With the help of many other researchers before me, I was able to produce a new oxygen isotope curve that communicates when cooling mechanisms originally began. With the help of many other researchers before me, I was able to produce a new oxygen isotope curve that communicates when cooling mechanisms originally began. With the help of many other researchers before me, I was able to produce a new oxygen isotope curve that communicates when cooling mechanisms originally began. With the help of many other researchers before me, I was able to produce a new oxygen isotope curve that communicates when cooling mechanisms originally began. With the help of many other researchers before me, I was able to produce a new oxygen isotope curve that communicates when cooling mechanisms originally began. With the help of many other researchers before me, I was able to produce a new oxygen isotope curve that communicates when cooling mechanisms originally began.
RICHARD L. NIELSEN (1964) Richard L. Nielsen passed away on December 5, 2019 in Golden, Colorado. He won his PhD in Geology at Cal in 1964, following BA and MA degrees at CalTech. Richard embarked on a career in mining geology, working for major corporations (Kennecott, Anaconda) and consulting in Colorado and Australia from 1990. In 1996 he was President of the Society of Economic Geologists, the premier international society of mining geologists. He was President of the S.E.G. Foundation in 2001-2003. Richard was a very successful and highly-regarded professional, who shared his enthusiasm for earth sciences with his colleagues, family, and wider society.

-By Fred Barnard (B.A. Geology, 1963)

PRISCILLA C. GREW (1967) The Galuskina et al. preprint for my new garnet is now online at American Mineralogist in press. Here is the link to a University of Nebraska news story about a new mineral being named in my honor: https://news.unl.edu/newsrooms/today/article/new-mineral-priscillagrewite-named-in-honor-of-renowned-husker-geologist/ In the story, I describe an all-nighter on the probe in fall 1966 analyzing Tiburon garnets. Best wishes and thanks for the memories!

Photo credit: Greg Nathan, UNL Communications

JIM MURRAY (1968) I'm working mostly at my emeritus home office as UW is closed except for essential work. My book project on Chemical Oceanography is essential for me, but not for UW. I also just wrote a paper on “Carbonate System Geochemistry of the Arabian Gulf.” pCO2 in surface seawater is supersaturated so ocean acidification is not a present problem. The question is why? Coral reefs produce CO2 but have been severely damaged. We make a good case for abiological CaCO3 formation.

MARC SEELEY (1969) After graduating from UCB in 1969 I was in the USAF as an Air Intelligence Officer using my geology acquired air photo interpretation skills. Then I was a staff geologist for the USDA - Soil Conservation Service. I worked on California north coast river basin erosion studies related to timber harvesting practices and working with ranchers and farmers on the design of small dams. I then completed my MS in Geology at Cal State Hayward (now East Bay) and was hired by Woodward-Clyde Consultants (WCC) where I worked as an engineering geologist on projects including the Trans Alaska Pipeline, PG&E nuclear power plant siting studies, regional fault studies in Costa Rica, geotechnical investigations for facilities development in Saudi Arabia, and evaluations of Dam Safety Policies and Procedures for the USDA. In the late 70’s I started a Geotechnical Engineering and Geology consulting business with a WCC colleague (Merrill & Seeley, Inc.). My focus was on active fault, landslide and geologic hazards investigations until the early 80’s when the emphasis of my work transitioned to soil and groundwater environmental investigations and remediation. In 1991 I started Environmental Geology Services, specializing in engineering and environmental geology and groundwater resources. After 45 years as a full time professional geologist I am now semi retired, doing selective work as Seeley & Associates. I will always remember Professor Charles Meyer who taught my introductory geology class at Berkeley, inspired me to major in geology and set me off on a most interesting and enjoyable career.

ROBERT BARKER (1971) It is nearly fifty years since I received my PhD in Economic Geology at Berkeley. After a career in international mineral exploration, I tell people that I am a “geologist by training”. I now consider myself a writer. My first book was The Devil’s Chosen, examining decision processes of the Holocaust. More recently I have written two international thrillers, with a geologist as the hero. Still looking for the movie contract. robertwbarker.com

Have an update you would like to share in next year’s publication? Go to eps.berkeley.edu and click on Connect With Us, or email eps_alumni@berkeley.edu. Alumni can also request to join our LinkedIn group; please find the group here: www.linkedin.com/groups/6927573
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