

EPICENTERS

JUDD A. AND MARJORIE WEINBERG COLLEGE OF ARTS AND SCIENCES

THE NEWSLETTER OF THE DEPARTMENT OF EARTH AND PLANETARY
SCIENCES AT NORTHWESTERN UNIVERSITY | 2017

Message From the Chair



Greetings to all friends of Earth & Planetary Sciences,

I have now entered my final year as department chair, and I am looking forward to passing the baton next year, so this will be my final message as chair. Serving in this role has certainly been challenging at times, but overall deeply gratifying. I am so proud of the state of our department. Granted, a few projects remain unfinished – for example, I have long wished to establish an alumni advisory board, but I have been reticent to add one more thing to anyone’s plate. However, I know we would welcome the opportunity to strengthen our connections with alumni. Despite such unfinished projects, there are many successes to celebrate. Yarrow Axford was promoted to tenured Associate Professor and Matt Hurtgen to Full Professor. The cover of this year’s newsletter highlights planetary science and our newest faculty colleague, Seth Jacobson, who received an early career award from AGU at this year’s fall meeting (see page 3). Additionally,

Assistant Professor Maggie Osburn became the third EPS faculty member in the past decade to win a Packard Fellowship (also described more fully on page 3)! Our graduate students are doing exciting and important work and finding success in academic and industry job markets, and our current undergraduate majors comprise one of the most cohesive and engaged groups I have seen. There have been some profound changes in the university’s administration recently, with both a new dean and new provost at the helm, but I believe they recognize and value EPS for our contributions to the university and our work on some of the most important issues facing humanity in the 21st century (natural hazards, such as earthquakes and climate change, as well as fundamental science questions pertaining to plate tectonics, earth materials and their properties, ocean acidification, and exobiology...just to name a few). This edition of the EPS newsletter will bring you up to speed on many of the exciting events in our department from the past year. I hope you enjoy it, and I wish you all the best in 2018.

Cheers,

Welcomes and Goodbyes

We welcome . . .

Seth Jacobson joined the EPS community in September as an Assistant Professor. Read more on page 3.

Meagan Ankney joined the EPS community in June as a Research Associate and TIMS Lab Manager. Read more in the adjacent box.

Robin Stark joined the EPS community in September as a Program Assistant and is happy to be back at her alma mater (BA Environmental Sciences '98).

We send well wishes to . . .

Program Assistant **Gina Allen** departed to pursue a career as a paralegal.

Postdocs **Xiaobing Liu** and **Xin Chen**—pictured here with Evanston-born Alice (4) and Eric (2)—both accepted faculty positions at Qufu Normal University in China.



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Meagan Ankney Joins EPS

EPS is excited to welcome Research Associate and TIMS Lab Manager, Meagan Ankney. Previously a lecturer at the University of Akron, Meagan joined EPS in June. She has a PhD from the University of Wisconsin-Madison, where she worked with her advisor Dr. Clark Johnson on understanding magmatic processes that occurred during the buildup to the caldera-forming eruption of Crater Lake in Oregon. In the lab, Meagan oversees the repair and maintenance of the TIMS, ICP-OES, IC, and other supporting clean lab systems. She also trains students in clean laboratory and mass spectrometry techniques and helps to develop new analytical methods.

Maggie Osburn Wins Packard Fellowship for Study of Microbial Dark Matter

The Packard Foundation recently awarded EPS Assistant Professor Magdalena Osburn a 2017 Packard Fellowship. The Packard Fellowship is one of the most prestigious early career awards for scientists and engineers, and it provides a very generous five year grant to support the research of young scholars. Maggie’s proposal was titled “Illuminating Microbial Dark Matter with Subterranean Geomicrobiology.” The Packard funds she receives will support her efforts to cultivate microbial taxa of the deep subterranean biome in her laboratory and elucidate their taxonomy, physiology, and fundamental biogeochemical functionality. Professor Osburn’s work has profound significance for our understanding of the origin and early evolution of life on Earth, as well as for identifying the most likely living systems (and their biosignatures) to inhabit other planetary bodies. She is the third EPS faculty member in the past decade to receive the prestigious Packard Fellowship, following in the steps of Professors Andy Jacobson and Steve Jacobsen. The department is ecstatic about this stellar recognition of Professor Osburn’s accomplishments and potential by the Packard Foundation.



Students/Faculty Establish Geoclub

The newly formed NU Geoclub is a community of undergraduates, graduate students, postdocs, and faculty who love the Earth. Geoclub hosts a weekly seminar series, plans outreach events to foster positive connections between NU and the local community, and organizes social events and field trips related to geology and environmental sciences. Find out more at <http://nuesc.weebly.com/>.

Latest Faculty Hire Brings Additional Planetary Science Expertise to EPS

The department enthusiastically welcomes new Assistant Professor Seth Jacobson. He arrived in the department at the beginning of September, just as AGU announced he had been awarded the Ronald Greeley Early Career Award in Planetary Science. Seth’s research focuses on the history of the Solar System and the bodies within it, including planets, moons, asteroids, and comets. He tests his hypotheses by constructing computational models and comparing the output to geological, astronomical, and cosmochemical measurements. His lab will use Northwestern’s Quest high performance computing cluster, as well as its own computational platforms.

In his approach to research, Seth examines data closely to determine the constraint that it truly poses for competing ideas; then, he builds models to test each of those ideas against that constraint. Using this approach, he created a novel clock that dated the Moon-forming impact on Earth by examining the highly siderophile (iron-loving) elements in the Earth’s mantle. Similarly, with colleagues, he used oxygen isotopes of the Moon and Earth combined with numerical models of planet

formation and differentiation to show that the Moon-forming impact must have led to an isotopic equilibrium between Earth and the Moon-forming disk about it.

Seth’s recruitment brings new planetary science expertise to Northwestern, something to which we have long aspired. He will enhance our research and teaching efforts, as well as our collaborative interactions with colleagues in Physics and Astronomy. Seth plans to add a number of planetary science courses to the department’s curriculum, while also teaching our long-standing introductory planetary science course, *Exploration of the Solar System*. In the spring quarter, he will teach *Cosmochemistry*, providing students the opportunity to learn from where everything ultimately originated. He also intends to teach a course on planetary physics and planet formation. He firmly believes in an active classroom where students engage fully with material, so his classes will be filled with discussion, problem-solving, and interaction. The EPS community extends a hearty welcome to Dr. Seth Jacobson!



The great comet McNaught (C/2006 P1) showing striations in its tail, as seen from ESO Paranal Observatory.



FACULTY HIGHLIGHTS

YARROW AXFORD's lab added exciting new capabilities this year, including a core scanner with non-destructive XRF, a color spectrophotometer, and other instruments that provide mm-scale assessment of sediment core composition. The new Geoperspectives on Climate and Life lab space, shared with Assistant Professor Maggie Osburn, will facilitate continued collaboration. Graduate students Laura Larocca, Everett Lasher, and Jamie McFarlin continued their research using a range of paleolimnological and geospatial methods to reconstruct past changes in Greenland's climate. Postdoctoral researcher Melissa Chipman (PhD UI-UC 2017) works to understand how temperature shifts may have affected medieval Viking settlements in Greenland. Undergraduates contributing to research in the lab this year included Karalyn Berman, Lucero Flores, **Barbara Gawin (BA 2017)**, Christine Lee, and Peter Puleo. Outside the lab, Yarrow developed a new graduate course on communicating science beyond academia. She also chaired a session at the December AGU meeting, "Past Climate Change in the Arctic and Subarctic: Lessons for the Future."

TRISH BEDDOWS spearheaded the March 2017 Yucatan experiential field trip for graduate and undergraduate students (see photos on pages 7-9) with the leadership and technical support of Prof. Brad Sageman, Prof. Dan Horton, Prof. Andy Masterson, and Grace Schellinger. The group of 18 explored the geology of the lowland Yucatan Peninsula of Mexico, including the reefs, bays, estuaries, beaches, modern and paleo coastlines, and then progressively older features inland. New activities this trip included time exploring a totally wild cave and accessing the exceptional back-stepping Pleistocene high stand reef structures exposed by the nearly 10m deep trenches excavated inside the XCaret tourism development. Research continues to deliver interesting results, with publications on hydrogeology and sea level aspects of both the Vista Alegre and Hoyo Negro geoaerchology projects. A further five papers are in various stages of review, including a paper first authored by **Dana Johnson (BA 2016)** based on sampling of actively growing microbialites in Laguna Bacalar during the Yucatan 2015 student trip.

CRAIG BINA returned to Tokyo last November to serve as the solid-Earth sciences representative of the American Geophysical Union (AGU) on the Program Committee of the first Joint Meeting of the Japan Geoscience Union (JpGU) and

AGU. The meeting was a remarkable success when held in Chiba, Japan, later in May. Craig traveled to Taiwan in February, to collaborate with former students **Yun-Yuan Chang (PhD 2014)** at Academia Sinica and **Po-Fei Chen (PhD 2002)** at National Central University and to explore some of the local geology in Hualien County. In March, he returned to Charles University in Prague as a visiting researcher, where he pursued several ongoing studies combining geodynamics, mineral physics, and seismology. One such study, relating a recent deep earthquake to the dynamics of Nazca subduction, appeared later that month in *Scientific Reports*. He was reappointed to the Editorial Board of the JpGU journal *Progress in Earth and Planetary Science*.

In the last year, **NEAL BLAIR's** Carbon-Biogeochemistry Laboratory has focused on being a part of the National Science Foundation's (NSF's) Intensively Managed Landscape - Critical Zone Observatory (IML-CZO). The "Critical Zone" is the part of the Earth's surface, soils, water, atmosphere and ecosystems critical for our survival. The lab group's part of the project is to determine how agricultural activities influence the export of carbon from land to streams and rivers. They also study the fate of carbon trapped by reservoirs, now recognized to be globally important in terms of carbon-sequestration and methane emission. As a member of the IML-CZO team, Neal recently visited the Yan'an region of China to evaluate potential research concerning the massive geoengineering experiment, the Gully Land Consolidation Project, on the Loess Plateau.

DANIEL HORTON's Climate Change Research Group (CCRG), in partnership with Northwestern's Institute for Sustainability and Energy (ISEN), welcomed its newest member, postdoctoral research scholar Jordan Schnell. Jordan, an atmospheric chemistry and climate scientist, will be working with a team of NU researchers on ISEN's Climate and Carbon Solutions initiative. Dan's graduate students, Yuxi Suo and Howard Chen enter year two of their NU tenure, with Yuxi engaged in air quality research and Howard investigating exoplanet atmospheres and habitability. Several undergraduate researchers have also joined the CCRG: Christopher Callahan studies Beijing's "airpocalypse" air quality events and Katherine Braun studies carbon storage in a Lake Michigan wetland. On the collaborative science front, Dan was part of a team of researchers that developed new methods to probabilistically

attribute extreme climate events. The work, published in the *Proceedings of the National Academy of Science*, resonated with the general public, particularly in the aftermath of Hurricane Harvey. Media interest also piqued, and Dan made his first live television appearance in an interview on WTTW's *Chicago Tonight*. Additional collaborative research efforts led to a study on West Nile Virus-climate linkages in *Proceedings of the Royal Academy B* and California drought research in the *Journal of Geophysical Research*. Beyond academic pursuits, Dan was also selected by AGU to represent the state of Illinois in their annual Congressional Visit Day, which brings scientists to Capitol Hill to meet with representatives.

MATT HURTGEN's research team seeks to better understand the couplings and feedbacks that link evolving ocean chemistry and the Earth surface carbon cycle. **Brian Kristall (PhD 2016)** recently published a portion of this work in *Palaeogeography, Palaeoclimatology, Palaeoecology* with Profs A. Jacobson and Hurtgen that explored a new model for the ancient seawater radiogenic strontium isotope record. The results indicate that enhanced hydrothermal and weathering input fluxes to the early Cretaceous ocean played a dominant role in regulating the marine sulfur cycle and CO₂ exchange among the atmosphere-ocean system during this interval of rapid biogeochemical change. Finally, Hurtgen welcomed first year PhD student Nilou Sarvian, interested in exploring the radiogenic and stable strontium isotope composition of Neoproterozoic carbonates to disentangle the influences responsible for massive carbon cycle disruption during this time.

STEVE JACOBSEN gave invited lectures at Université Pierre et Marie Curie in Paris and in the Jackson School of Geosciences at UT-Austin, where he was a DeFord Lecturer. Jacobsen also spoke at the 2017 Z Fundamental Science Program Workshop at Sandia National Laboratories, where he is developing a project to use the Z Machine, the world's most powerful radiation source, for shockwave experiments on Earth materials to conditions of superearth interiors. Former Postdocs, **Xiaobing Liu** and **Xin Chen** published two papers this year in *Scientific Reports* with Jacobsen and Bina, one on high-pressure synthesis and properties of ultrahard carbon-boron-nitrides with physical properties rivaling diamond, and the other on mechanical properties of boron-doped diamond, a potential semiconductor for electronics in extreme conditions. Steve's mineral physics group welcomed NSF-Postdoctoral Scholar Alisha N. Clark, who studies the physical properties of silicate melts.

ANDY JACOBSON welcomes two new group members. Dr. Meagan Ankney is a research associate and manager of the Radiogenic Isotope Geochemistry Clean Laboratory. Dr. Ben Linzmeier, a post-doctoral fellow advised by Jacobson, Hurtgen, and Sageman, joined the department as part of the Ubben Program for Climate and Carbon Science administered through ISEN. His research will use Ca isotopes to examine "deep time" ocean acidification events. Graduate student Gabby Kitch, awarded a prestigious NSF graduate research fellowship, recently attended the Urbino Summer School to further her research using B and Ca isotopes to constrain ocean acidification during the Paleocene-Eocene Thermal Maximum.

During the summer, graduate student Annie Nelson conducted fieldwork in Iceland to support her research focusing on the Ca and Sr isotope geochemistry of basalt weathering. Former graduate student, post-doc, and lab manager **Greg Lehn (PhD 2016)** published a paper on his research using the major ion and isotope geochemistry of North Slope Alaskan rivers to quantify seasonal active layer dynamics. Jacobson continues to direct Northwestern's Environmental Sciences Program.

SETH JACOBSON - see page 3.

DONNA JURDY's research focuses on tectonic and volcanic activity on terrestrial planets Venus and Mars, as well as the outer satellites. Examination of the cratering history of these bodies gives additional insight on surface processes. Donna continues her work on topographic features on Venus, comparing its enigmatic mountain belts to possible analogues on Earth. Working with the Superior Province Rifting Earth Scope Experiment (SPREE) project, she uses seismic reflection data to provide velocities and structural information related to the North American Mid-Continent Rift. With the Association for Women Geoscientists (AWG), she chairs their Professional Excellence Award, an award she proposed. Currently, she focuses on building an endowment for the AWG's Chrysalis Scholarship to enable women graduate students to finish their degrees. She regularly serves on EPA, NASA, NSF, and USRA panels, such as for Postdoctoral Fellowships, and has successfully advised students on their fellowship applications. This year Donna participated in NSF's GeoDES program to promote diversity in the Earth Sciences.

As Professor Emeritus, **EMILE OKAL** pursues his research on tsunamis and deep earthquakes with his continuing graduate students. He is also involved in worldwide efforts for the preservation of historical seismological archives. This year, he gave invited lectures in Tottori and Kobe, Japan; Hanoi; and at the College de France in Paris. He returned to Vietnam in December for a 15-hour course; was in the field in Mongolia, Indonesia, and Greece; and also lectured in Cuba and Myanmar.

For the last three years, **ABRAHAM LERMAN's** research has continued to be in the field of the biogeochemical cycles of the past and present and in planetary science. In the field of terrestrial geochemistry, Abe Lerman and Fred Mackenzie, continuing their long-time collaboration, completed two articles, "Carbonate Minerals and the CO₂-Carbonic Acid System" for *Encyclopedia of Geochemistry* and "Global Biogeochemical Cycling" for *Oxford Research Encyclopedia of Environmental Science*. In the field of planetary science, Abe Lerman presented on behalf of co-authors **Ashley E. Gilliam (PhD 2016)**, and Dr. Jared Wunsch, "Explicit and Asymptotic Solutions of Simultaneous 1st-order and Riccati Equations for a Gas Reaction System" at the 2017 European Conference on Applied Mathematics and Informatics in Cambridge, UK. He also chaired one session at that conference.

This has been a busy year for **MAGGIE OSBURN** and the Osburn Isotope Geobiology Laboratory, with new students, funding, and field opportunities. The lab is up to full steam

with two graduate students and six undergraduates, working on an array of topics. Maggie's team, including graduate student Caitlin Casar, continue their work at the Deep Mine Microbial Observatory. Caitlin is having success cultivating microbes from deep underground and understanding their lipid biosignatures. Work also continues in Greenland with graduate student Jamie McFarlin and undergraduate Hannah Dion-Kirshner. Jamie has created an isotopic record of hydroclimate from Northwest Greenland from the past two interglacial periods and is now comparing that record to a modern latitudinal transect. Hannah is working on her senior thesis project following biomarkers from source to sink in a single lake basin, then back four thousand years. A new project focusing on understanding the geomicrobiology of biofilms in lava tube environments was funded by the NASA PSTAR program and began this year with a kick off meeting and field trip to Lava Beds National Monument. Lastly, Maggie was honored with a prestigious Packard Fellowship.

BRAD SAGEMAN divided his time this past year between administration, graduate student advising and research (with PhD students Matt Jones and Jiuyuan Wang), teaching a new class on energy and climate, and work on sustainability (as co-chair of the Sustainability Council and co-director of ISEN). Research highlights include co-authorship of a *Nature* paper with **Steve Meyers (PhD 2003)**, and his PhD advisee, Chao Ma. He also continues to collaborate with department colleagues, Hurtgen and A. Jacobson, on application of Ca, Sr, S and C isotopes to studies of ancient biogeochemical perturbations, specifically ocean acidification. Thanks to support from the Ubben gift to ISEN, Matt, Andy and Brad recruited Dr. Ben Linzmeier, a freshly minted UW-Madison PhD, as a post doctoral scholar. Lastly, Brad continues to collaborate with external colleagues on an NSF Earth-Life Transitions project to study the Cenomanian-Turonian extinction event in the Western Interior basin, as well as various other Cretaceous projects in Asia, Europe, and Australia.

SETH STEIN, is making the Midcontinent Rift great again, along with Professor Carol Stein, grad student Reece Elling, and other co-authors. The rift, which started to split North America 1.1 billion years ago, built the beautiful cliffs around Lake Superior. Many geologic maps confused the rift with another structure

in southeast Canada, the Grenville Front. On these maps, the Grenville Front extends southward into the US, cutting off the Midcontinent Rift in southern Michigan. Using gravity data, Stein and colleagues found that what had been mapped as the Grenville Front in the central US is really the Midcontinent Rift, so its east arm extends south from Lake Superior through Michigan, Ohio, Kentucky, Tennessee, and Alabama, and its west arm extends as far south as Oklahoma. Hence, the rift is much greater than traditionally mapped. Other research with grad students Eddie Brooks, Leah Salditch, and James Neely explored a range of issues in earthquake recurrence and hazards, including the hazard from earthquakes induced by oil and gas development and the fact that large earthquakes often occur in temporal clusters. Seth's geoscience community activities include serving as President-Elect of the AGU's Natural Hazards focus group.

Over the last year, **SUZAN VAN DER LEE** worked with her colleagues from the P&A and EECS departments to deliver a new NSF-funded graduate training program in Data-Driven Discovery in Astrophysics and Geophysics (IDEAS). She also returned to teaching her experiential-learning course on scientific programming in Python. Using SPREE data and building on a detailed model of crustal discontinuities published in JGR last year, Van der Lee worked with Trevor Bollmann to complete his teleseismic tomography study of the Midcontinent Rift. Van der Lee also worked with **Mike Witek (PhD 2017)** on preparing his dissertation research on seismic noise analysis and lithospheric units of East Asia for publication. This and other research in her group into Earth structure lays the groundwork for geodynamics/tectonophysics research, full characterization of seismic sources, and seismic hazard assessment. Students Vivian Tang, Boris Rössler, and JaCoya Thompson are addressing characteristics of both residual signals and noise in seismic time series to facilitate and expand this type of research. Data Scholar Kevin Chao co-advises Vivian on one of her three research projects: systematically detecting dynamically triggered seismic events. Lastly, Van der Lee works with research associate Mitchell Barklage on the maintenance, research, and outreach connected to NUDS (Northwestern University's Distributed Seismometers), a group of two professional and two educational seismometers.



NEW POSTDOCS & GRAD STUDENTS

EPS Welcomes Five New Postdocs:

Kevin Chao, a data science scholar in the Northwestern Institute on Complex Systems (NICO), works with Professor Suzan van der Lee. His research focuses on the physics of earthquake processes in active fault zones. This past year, Kevin's NSF-supported research on slow earthquakes in Taiwan was published in the *Journal of Geophysical Research: Solid Earth*. Currently, he is involved in the big data study of cross-disciplinary research subjects, such as applying machine learning algorithms to geoscience problems, developing a software package for seismology study, and adapting the signal process techniques to forecast the amount of solar radiation that solar panels can receive.

Melissa Chipman began working as a postdoctoral researcher in Professor Axford's Quaternary Sediment Lab in August. She graduated from the University of Illinois in May with a PhD in Ecology, Evolution, and Conservation Biology. Currently, she uses chironomid remains in lake sediments from high-elevation sites in southern Greenland to infer quantitative summer temperature estimates over the past 2000 years. Melissa is particularly interested in the expression of the Little Ice Age and Medieval Warm Period in southern Greenland, given that instrumental temperature records suggest recent cooling in this region, in contrast to overall Arctic warming trends. She also works with the Geoclub to create a weekly seminar series for students and postdocs to showcase their research and practice professional talks.

Alisha N. Clark joined Steve Jacobsen's mineral physics group as an NSF-Postdoctoral Fellow in geophysics. Alisha's research deals with the physical properties of silicate melts, which she applies to understanding the nature of the lithosphere-asthenosphere boundary and deep hydrous melts in the mantle. She is working to provide new constraints on the melt fraction derived from seismic wave velocities. Alisha received her PhD in 2015 from UC-Davis and spent 2016 as a Postdoctoral Researcher at the Université Pierre et Marie Curie in Paris.

Benjamin Linzmeier started as a postdoctoral research fellow at the beginning of September. He will be working on several different projects focusing on ocean acidification under the advisement of Professors Andy Jacobson, Matt Hurtgen, and Brad Sageman. Ben joins us from the University of Wisconsin-Madison where he defended his PhD in August. As part of his dissertation, he used geochemical sampling on the scale of micrometers to determine the depth at which ammonite hatchlings lived in the water column and to find daily behavior recorded in the shell of modern Nautilus. One chapter of his dissertation was recently accepted for publication in *EOS*, and he is currently revising a manuscript for *Paleobiology*.

Jordan L. Schnell began his postdoc in September working with Dan Horton in the Ubben Program for Climate and Carbon Science administered through ISEN. He received his PhD in Earth System Science from the University of California, Irvine, in the fall of 2016 and was a postdoctoral fellow at Princeton University the following year. Jordan's research focuses

on atmospheric chemistry and climate interactions, where he uses chemistry-climate models (CCMs) to understand the chemical and meteorological drivers of pollution episodes. He is especially interested in understanding how natural and anthropogenic feedback processes contribute to pollution episodes and how they can be best represented in CCMs. Additionally, he is leveraging CCMs to understand how a transition from an internal combustion to an electric vehicle fleet would impact air quality in the US, as well as heavily polluted regions such as India and China.

EPS also Welcomes Three New Graduate Students:

Hannah Bausch will be studying shockwave properties of minerals with her advisor, Steve Jacobsen. She received her BS in Geophysical Sciences and Environmental Sciences in 2017 from the University of Chicago.

James Neely will be studying seismology and earthquake hazards with his advisor, Seth Stein. He received his MS in Geosciences in 2016 from Pennsylvania State University, and his BA in Physics and History in 2010 from Bowdoin College.

Nilou Sarvian will be studying how elements cycle through the atmosphere, Earth, and oceans with her advisor Matt Hurtgen. She received her BS in Chemistry in 2015 from the University of California at Santa Barbara.

GRADUATE STUDENT UPDATES

Trevor Bollmann is currently working for Chevron in Covington, LA as he finishes his thesis work with Suzan van der Lee and Brad Sageman. At Chevron, he is working as a Technical Geophysicist, supporting multiple assets. When not swamped with work, he develops workflows to expedite seismic interpretation.

Eddie Brooks investigates performance of earthquake hazard maps. He recently published new work on the USGS's hazard model for induced seismicity in the central and eastern US and presented this work at SSA, GSA, and AGU. He has been recognized with a renewal of his fellowship with the Institute for Policy Research. Eddie spent the past summer working in Detroit for Ford Motor Company as a data scientist analyzing the performance of electric vehicles.

Caitlin Casar's research centers on characterizing the habitability of the continental deep subsurface by observing microbes inhabiting fracture fluids at depths of 800 to 4,850 feet. She has been studying microbes that derive their energy from minerals while at the Deep Mine Microbial Observatory located at the Sanford Underground Research Facility in Lead, SD. She is working in the lab to isolate and characterize these organisms through batch cultivation experiments.

Howard Chen is working on two projects using a range of climate models. The first, which he will be submitting to an AGU journal for publication, involves a 1-D climate model to predict how volcanic eruptions may affect future climate. The second project uses a 3-D chemistry-climate model to predict the behavior of biosignatures on extrasolar planets such as Proxima Centauri b.

Reece Elling's main research involves studying North America's Midcontinent Rift and how it can provide insight into the evolution of continental rifts in general. This work was presented at the 2017 GSA meeting and is included in an upcoming, co-authored paper in *GSA Today*. Reece also worked with Adjunct Prof. Christopher Scotese on paleo-plate tectonic reconstructions and paleomagnetism of the Precambrian. He presented a model of this reconstruction at the William Smith Meeting 2017: Plate Tectonics at 50, held in London.

Phylindia Gant is investigating the equation state of a single crystal of magnetite up to 31 GPa in an effort to better constrain the bulk modulus. She is also interested in inspiring the next generation of Earth scientists, which she does through her outreach program, *Engaging Future Scientists*.

Matt Jones just returned from a trip aboard the JOIDES Resolution marine research coring vessel on International Ocean Discovery Program Leg 369. There, he worked alongside a team of seafaring scientists for two months to recover rock cores from below the

ocean floor. They hope that the cores will provide rare sedimentary records of climatic and tectonic conditions at the southern high latitudes during the Cretaceous Period. Matt's AGU presentation focused on geologic projects from the Western Interior Basin (US) developed with his advisor, Brad Sageman.

Gabby Kitch received the three-year NSF Graduate Research Fellowship. She spent the year learning the application of double-spike techniques in Andy Jacobson's Radiogenic Isotope Laboratory. She has been measuring the $\delta^{44}/^{40}\text{Ca}$ isotopic composition of foraminifera from the Paleocene-Eocene Thermal Maximum and presented these results at the 2017 AGU meeting. This past summer, she attended the Urbino Summer School of Paleoclimatology, allowing her to expand her knowledge base regarding paleoceanography.

Laura Larocca studies alpine glaciers and ice caps on Greenland's coastal margin beyond the ice sheet to record climate variability through the Holocene. She utilizes sediment core measurements from glacial-fed Per's Lake and geospatial analysis of satellite images. She also constructed a complementary record of recent changes in equilibrium line altitude (ELA) for the upstream alpine glaciers. This approach allows her to possibly link changes in ELA to specific sediment parameters. Ultimately, she aims to reconstruct glacier variability through the entire Holocene epoch, and to compare this history with 20th and 21st century changes.

Everett Lasher is continuing his research on the Holocene climate history of West Greenland. Look for a new paper about the climate history of South Greenland over the last 3000 years, including implications for Norse settlement and abandonment of the island.

John Lazarz continues his work studying the effects of pressure and temperature on the elastic properties of hydrous garnets. This work will be used to create a more comprehensive mineralogical model of the region between the Earth's upper and lower mantle. He presented a poster at the 2017 COMPRES Annual Meeting and prepared a manuscript for submission to PEPI titled "High-pressure phase transition of clinoenstatite". He also participated in a panel discussion on lab internships (representing Los Alamos National Laboratory) at the 2017 Stewardship Science Academic Programs Annual Review Symposium.

Jamie McFarlin studies paleoclimate records from Greenland on her NSF Graduate Fellowship, working with advisors Yarrow Axford and Maggie Osburn. She is currently working on assessing how hydrogen isotope ratios in modern sedimentary lipids reflect modern environmental waters in Greenland. She had the opportunity to present her research to Prince Albert of Monaco at the 2016 AGU meeting. She also recently

submitted a paper discussing summer temperature estimates through the Holocene and Eemian in northwest Greenland, and she co-authored an article on climate change for Northwestern's *HELIX Magazine*.

Emiliano Monroy-Rios studies water-rock interactions, geochemistry of coastal carbonate aquifers, and submarine groundwater discharge. He cave dives to access the geology of the marvelous underwater cave systems in the Yucatan Peninsula. There, he collects samples for geochemical analyses. Recently, he has been working on developing a conceptual model for the formation of the Chicxulub Ring of Cenotes, providing mechanisms linking impact geometry, geochemistry, and hydrogeology on a platform scale.

Annie Nelson spent her summer conducting fieldwork in Iceland. The first month consisted of collecting water samples from farmers' geothermal wells, as well as 13-hour hikes with a 70-pound backpack full of water and rocks. The latter half of her fieldwork was focused on collecting zeolite minerals in southeast Iceland while precariously balancing on the edge of a cliff. After returning with over 1,200 pounds of samples, Annie has been in the lab processing her samples to prepare for Ca and Sr isotopic composition analysis.

Boris Rösler, a fellow of the IDEAS program, studies surface-wave amplitude variations. After determining the source process of earthquakes from the spectral amplitudes of surface waves, he compares synthetic seismograms, calculated using different Earth models, with observed seismograms, to derive conclusions about the origin of the distinct patterns of surface-wave amplitudes observed in the dense seismic array of EarthScope. Boris is currently developing a web-based visualization for surface-wave radiation patterns, to be extended to moment tensor inversions.

Amir Salaree works on a sufficiency level for the amount of physical details in source and bathymetry that control tsunami generation and propagation. He published two papers on tsunamis in the Persian Gulf as well as Kamchatka. From his long-time TA-ship for Earth 202, Amir published a paper advocating the use of smartphones as powerful educational tools in such classes and received the Teaching Certificate from Northwestern's Searle Center for Advancing Learning & Teaching. His recent piece on the Iran-Iraq earthquake appeared in *The Conversation* and the *Chicago Tribune*.

Leah Salditch presented at five conferences in 2017, including one in Switzerland on the topic of probabilistic seismic hazard assessment, where she received the Seismological Society of America Student Presentation Award. Leah also became the Student/Early Career Representative for the Natural Hazards Focus Group of the AGU. She continues her research on large earthquake temporal clusters and the proposed Long-Term Fault Memory Model, as well as the intensity distribution of the 1952 Kern County, CA, earthquake.

Nooshin Saloor studies earthquake source parameters, specifically on extending the calculation of the slowness parameter Θ , in depth and distance. Her research resulted in the publication of two papers. Currently, she has begun work on a theoretical explanation for the depth-distance correction in earthquake body wave magnitude.

Yuxi Suo focuses on atmospheric stagnation analyses in order to quantify how anthropogenic climate change has played a role in air quality issues. This research will investigate which meteorological factors best explain the change of stagnation events from a seasonal perspective. This past summer, she also attended a National Center for Atmospheric Research (NCAR) Community Earth System Model workshop.

Vivian Tang works on a systemic survey of triggered seismic events in the US, which has the potential to better explain the fundamental process of dynamic triggering. Vivian is also exploring the velocity structure of the topmost outer core using global multiple SKS phases and investigating deep mantle structure beneath East Asia by lithosphere-corrected, body-wave tomography. This past summer, she interned at IRIS DMC in Seattle to collect ocean observatories initiative data.

Jacoya Thompson uses data from the SPREE stations that were installed along the Midcontinent Rift from April 2011 through October 2013 to identify the sources of low frequency culture noise found in the seismic time series data.

Fei Wang works on a computer program providing graphical results of the effects that water and iron content in the nominally anhydrous minerals in the Earth's mantle transition zone have on the thermodynamics and seismic wave speeds and their discontinuity structures. He collected results from mineral physics literature to build an elasticity database for correlating the effects of water and iron contents on the physical properties of the minerals. He presented this work in a poster at this year's COMPRES meeting.

During the past year, **Jiuyuan Wang** continued his work on the application of Ca and Sr isotopes in major transitions during Earth history, such as the end-Permian mass extinction and Neoproterozoic Snowball Earth event.

Michelle Wenz studies mineral inclusions trapped inside of diamonds to understand the origin of Earth's water. She has a set of nearly 100 diamonds from a superdeep locality in Juina, Brazil that brings up minerals from depths greater than 400 km. To study these inclusions, Michelle is developing a high-throughput X-ray method at the Advanced Photon Source at Argonne National Lab. Michelle presented a poster at the COMPRES meeting in July in New Mexico. See her award-winning photo of a superdeep diamond on page 10.



2017 Graduation Spotlight & Awards

Doctoral Degrees Conferred

Michael Witek

*Lithosphere-Asthenosphere
Structure of East Asia from Ambient
Noise Tomography*

Grace Andrews

*Carbon Cycling of Glaciated
Landscapes: Investigation with
Strontium Isotope Geochemistry*

Bachelor Degrees Conferred

Nicholas Ambruz
Jane Berkowitz
Peter Carlin
Luis Cartagena
Barbara Gawin
Rachel Inderhees
Bethany Ketchem
Mark Schmid

Department Student Awards*

Matthew Jones and **Amir Salaree**
Marion Sloss Award for Outstanding
Graduate Teaching Assistant

Everett Lasher and **Michael Witek**
Horace A. Scott Award for
Excellence in Graduate Research

Nicholas Ambruz
Seymour Schlanger Undergraduate
Earth Science Award

*These awards are made possible by
the generous support of our alumni.



Michelle Wenz received an honorable mention from Northwestern's Science in Society Scientific Images contest for her superdeep diamond image (above).

A (Field) Trip Down Memory Lane

We received several emails from former students and faculty in response to the Baraboo Field Trip piece in our 2016 newsletter. Excerpts included below. How long have we been visiting Baraboo? We refer to the anniversary cake made for us by a local baker affiliated with the church in Fort Atkinson, WI, where we stop each year for a chicken dinner. Church records indicate that the 2017 trip was our 91st visit.



Byron L Ristvet (PhD 1977) reminisces about his participation as a grad student: "I made four trips to the Wisconsin Dells, Baraboo, and Devils Lake as part of the Geology 101 annual field trip. . . . Those classes were about 120 students (three charter buses). Four graduate student lab instructors would drive up in a university station wagon ahead of the main group to ensure that lodging at the Riverside Inn at the Wisconsin Dells was coordinated. . . . The students would get a taste of sedimentary rocks and stratigraphy at the Dells, structural geology at Baraboo, and quaternary geology at Devils Lake, plus a discussion of the ancient Native American mounds. Faculty would usually include Larry Sloss, Ed Dapples, Skip Nobles, Bill Krumbain and Fred Mackenzie. . . . I fondly remember those days and the outstanding education I received in old Locy Hall."

Timothy Whitten (Faculty 1958-81) recalls "back in those days, there was a graduate-student, two-to-three-day field course almost every year to the Copper Country. . . . Though not required, virtually every graduate student and faculty member attended annually. . . . Of course, Larry Sloss initiated the graduate student field trip to Montana (occasionally Colorado) in the '50s—wonderful geological experiences for about 10 days, heading west by Great Northern train making an unscheduled stop at Whitehall, Montana, for our party; we rented a church school bus for local transport—either Larry Sloss or I drove the bus, getting it . . . all sorts of places to which it had never been before!"



Times Have Changed!

1959:
Larry Sloss, front and center, leads a field trip to Whitehall Mountain. Who else do you recognize? (photo provided by Timothy Whitten)



2016:
Trish Beddows with students in Earth 331, *Field Problems in Sedimentary Geology*, leaving for a trip to Utah and Colorado.

ALUMNI NEWS

Grace Andrews (PhD 2017) finished her PhD as a Postdoc at the University of Southampton, UK. She successfully defended her thesis, published a paper, gave two talks at the Goldschmidt Conference in Paris, and was awarded a grant from the Geologists' Association for her upcoming fieldwork with the Oman Drilling Project.

Rosemary Bush (PhD 2014) is currently in a one-year appointment as a Weinberg College Adviser as well as a Lecturer in EPS - she will be teaching Environmental Science 201 in the spring quarter. She welcomed a happy baby, William Seungman Bush Won, in January.

Clayton Brengman (BA 2012) is currently a grad student at the University of Iowa Department of Earth and Environmental Sciences.

Alice Carter (BA 2012), a grad student in Duke's Program in Ecology, has received a fellowship from the American Meteorological Society. She now travels in Myanmar.



Laurel Childress (PhD 2016) concluded her work at Woods Hole Oceanographic Institution as a Postdoc and began working for the IODP with **Katerina Petronotis (PhD 1992)** and **Gary Acton (PhD 1990)** at Texas A&M University as an Expedition Project Manager/Staff Scientist. Her first expedition will be in October 2018 to the South Pacific Ocean.

John DeLaughter (PhD 1999) happily lives on his Hunter-320 and plans to head for the Gulf, then off to the Dry Tortugas.



Sue Griesbach (BA 1980) retired from Chevron R&D in 2003, after 20 years, and spent the next 8 years in software development, providing IT services to start-ups. In 2011 she started her own consulting company ClearbirdTech. The skipper of her C385 sailboat, she serves on the board of SoCal PHRF, which oversees sailboat racing.

Alice Gripp (PhD 1994) reports that her orchid plantation in Santa Barbara, CA, remains safe for now, despite the incessant fires burning nearby.

Benjamin Heath (BA 2012) is currently a graduate student at the University of Oregon Department of Earth Sciences.

George Helfrich (PhD 1990), currently at the Tokyo Institute of Technology Earth-Life Science Institute, was elected an AGU Fellow for "pioneering seismological and thermodynamic studies of the Earth's core."

Mitchell Kirshner (BS 2015) is working as a propulsion plant test equipment engineer at General Dynamics Electric Boat. He also continues his NU research on the Martian volcano Olympus Mons at Worcester Polytechnic Institute, where he studies for an MS in Systems Engineering. **Keith Koper (BA 1993)**, professor and director of the Seismograph Stations at University of Utah, works with **Hao Zhang (Postdoc 2016)**.

Bob Langan (PhD 1981) retired from Chevron in 2013 after 32 years in R&D. As a geophysical consultant at MEQ Geo, he specializes in microseismic monitoring of oil/gas reservoirs and mining, induced seismicity, and vertical seismic profiles.

Alberto Lopez (PhD 2007) reported from Puerto Rico that his immediate family and house are safe after Hurricane Maria, but his garden and numerous trees were lost.

Audeliz Matias (PhD 2005), promoted with tenure to Associate Professor at Empire State College, New York, now serves as the chair of the Natural Sciences Department. She received the SUNY Chancellor's Award for Excellence in Faculty Service.

Byron L Ristvet (PhD 1977) is retiring from the Defense Threat Reduction Agency after 43 years working on the effects of nuclear weapons on the solid earth. He participated in over 200 underground nuclear tests and directed clean-up programs worldwide. In Switzerland, his team was led by Bernhard Einstein, Albert's oldest grandson. Byron will continue teaching as a part-time Sandia Lab senior fellow.

Michael Robotham (BA 1988) transferred to the Natural Resources Conservation Service headquarters in DC after six years in Lincoln, NE. He and his wife are now empty-nesters, with their son in the Peace Corps in Panama and their daughter in her second year at WSU.

Brian Shiro (né White; BA 2000) will soon complete his PhD at the University of Hawaii in the Department of Geology & Geophysics. He recently became a Supervisory Geophysicist at the USGS Hawaiian Volcano Observatory after 11 years at the NOAA Pacific Tsunami Warning Center. He also serves as the Advanced National Seismic System coordinator for the Hawaii Region.

Paul R. Stoddard (PhD 1989) retired from Northern Illinois University, Geology and Environmental Geosciences after 29 years teaching, with a five-year term as President of the Faculty Senate, then three years as University Faculty Advisor. A longtime member of the DeKalb County Board, he is now on the ballot for State Representative from the 70th District to the Illinois Legislature.

Joshua Townsend (PhD 2016) recently married Katelin Fisher and moved to Albuquerque, NM, to begin a postdoc in High Energy Density Physics Theory at Sandia National Laboratories. He was honored with the 2017 Mineral and Rock Physics Graduate Research Award at the fall AGU meeting for outstanding contributions during PhD research.

Bob Wallace (BA 1938) recalled his time as a member of NU Geology in his oral history: "Earthquakes, Minerals, & Me": <https://pubs.usgs.gov/of/1996/of96-260/> **Michael Witek (PhD 2017)** successfully defended his thesis and works on publishing results concerning the cluster analysis of localized dispersion. Moving to South Korea as a postdoc with Professor Sung-Joon Chang at Kangwon National University, he plans to model radial anisotropy of the mantle.

Timothy Whitten (Faculty 1958-81) is preparing for the 2018 IAMG 50th Reunion Annual Meeting in the Czech Republic. This brings him full circle after the NU Geology faculty attended the ill-fated 1968 International Geological Congress in Czechoslovakia, when Soviets invaded. The International Association for Mathematical Geology was founded, nevertheless. At that Prague meeting, **Larry Sloss (Faculty 1947-1996)** recounted that US Ambassador Shirley Temple Black's official limousine, decked with US flags, led the vehicle caravan out of the city.

EPS OUT & ABOUT IN 2017

Hello from Chile!

I am currently studying abroad, taking classes in Chilean history, culture, and geology. In my free time, I have traveled to spectacular places like the Atacama Desert, the Andean Cordillera, and the coast of the Pacific Ocean. Chile is an absolutely amazing place -- I am loving it!

-Kate Haile (junior EPS major)



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Graduate student Eddie Brooks at the April 22, 2017 Chicago March for Science.

The 2017 Solar Eclipse was a big hit with the EPS crowd. We came home with the following photos and stories:



Geoclub traveled to Shawnee National Forest to experience totality.



The biannual trip to the Yucatan Peninsula took place from March 17th to 26th. The mixed group of undergraduate and graduate students was led by Professor Trish Beddows.

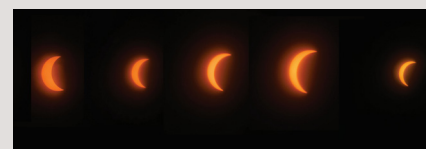


Professor Steve Jacobsen was on Mount St. Helens during the eclipse, installing a network of seismometers with colleagues from the University of New Mexico.

Front cover:

An artist's rendering of a forming star with a nebular disk around it. Earth and the rest of the Solar System grew from such a disk. Copyright ESO/Luís Calçada (luiscalcada.scienceoffice.org)

We appreciate photo contributions from alumni, faculty, and all members of the EPS community.



Graduate students John Lazarz and Michelle Wenz observed the solar eclipse from the lakefront and took these photos with a Nikon DSLR and NASA eclipse glasses.

How Can I Contribute?

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