

EPICENTERS

JUDD A. AND MARJORIE WEINBERG COLLEGE OF ARTS AND SCIENCES



THE NEWSLETTER OF THE DEPARTMENT OF EARTH AND PLANETARY
SCIENCES AT NORTHWESTERN UNIVERSITY | 2016

Message From the Chair



Greetings to all friends of Earth & Planetary Sciences,

With this issue of our annual newsletter, we welcome some new (and not

so new) members to the department, provide the usual updates on faculty and graduate student activities, and tell a few other stories of life in our little corner of the earth science world. As in past years, there is a long list of achievements and honors accrued by our faculty and students that continue to make us proud - you will find the details in Faculty Highlights and Graduate

Student Updates. Some of the most significant advances this year include the promotion of Steve Jacobsen and Andy Jacobson to the rank of full professor (congratulations!), and the selection of Earth & Planetary Sciences to join the group of departments at Northwestern which confer the Nemmers Prize (see article herein for details). Our department is honored and thrilled at the prospect of awarding the Nemmers Prize to outstanding leaders in the earth sciences every other year from now on. I know I speak for all of us in the department when I say, we send our warmest regards to you and your families and wish you the best in 2017.

Bradley B. Szegem

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EPS Welcomes and "Until Next Times"

In this section, we'd like to show off all the new members of the EPS community, while also sending good wishes to those who have recently left us. Of course, "goodbyes" were a bit too sad, so this year we've opted for, "until next time!"

Welcome...

On September 2, 2016, **Trevor and Morgan Bollman** welcomed their daughter, **Evan Rennes Bollmann**, She weighed 9 lbs 1 oz and was 20 inches long at birth.



Evan Rennes Bollmann

Maggie Osburn and Mitchell Barklage welcomed their son, **Harris Glenn Barklage-Osburn** into the world on March 30, 2016.



Harris Glenn Barklage-Osburn

Gina Allen is the department's new Program Assistant. She previously worked for Northwestern's Psychology Department. Gina joined the EPS community in September of 2016.

Two new Research Associates, **Mitchell Barklage** and **Andy Masterson**, have joined the department staff. See "Meet Our New Research Staff" on page 3 to learn more about their work.

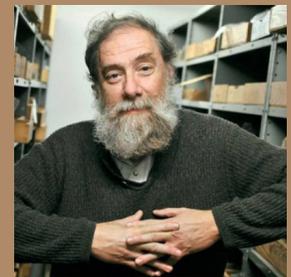
Until Next Time...

Program Assistant **Alexis McAdams** departed to pursue a graduate degree in Freshwater Sciences at the University of Wisconsin-Milwaukee.

Post-Doc **Hao Zhang** completed his work with Professor van der Lee and is now a Teaching Assistant in the Department of Computer Science at the University of Utah.

Visiting Assistant Professor **Matt Rossi** accepted a position as a Post-Doctoral Research Scholar with the Earth Lab team at University of Colorado Boulder.

A Special Welcome to Adjunct Faculty Chris Scotese



The department is thrilled to welcome Prof. Christopher Scotese as an adjunct member of the faculty this year. When Chris retired from the University of Texas, Arlington in 2013 he relocated to Evanston, where his sons live, and started showing up at our weekly seminars. Over the years, Chris has been a consistent departmental visitor, and has presented a number of seminar talks on his research. After his move, it was not long before he began to make contributions to the senior honors thesis studies of some students, provide guest lectures in classes, and start discussions about teaching a course focused on his current major project titled "Earth History, the Evolution of the Earth System." What a stroke of luck for EPS that Chris landed in Evanston! We feel very fortunate that our students and faculty can benefit from his continued scholarship on paleogeography and Earth history.

The Department of Earth and Planetary Sciences Chosen to Join Prestigious Nemmers Prize Program

During the 1990's Northwestern University introduced the Nemmers Prize, an award designed to recognize scholars who have made major contributions to new knowledge or the development of significant new modes of analysis and whose work is of lasting significance in their field of study. The award was made possible through bequests from the late Erwin E. Nemmers, a former member of Northwestern's Kellogg School of Management, and his brother the late Frederic E. Nemmers, both of Milwaukee, Wisconsin.

Recipients of the prize are awarded \$200K, and provided with support for a quarter of residence at Northwestern, during which they present lectures, participate in departmental seminars, and engage with Northwestern faculty and students. The Nemmers Prizes are awarded every two years.

The first disciplines to be recognized in 1994 by the Nemmers Prize were Economics and Mathematics. Music Composition was added in 2004 and Medical Sciences in 2014. The Nemmers endowment has now grown sufficiently for the next discipline designated in the original bequest to be added – the Nemmers brothers determined it should recognize scholars in the Earth Sciences.

In the Northwestern press release about the Nemmers Prize in Earth Sciences, department chair Brad Sageman was quoted as follows: "We live in a time when fundamental Earth processes, such as earthquakes and climate change, have major impacts on increasing numbers of people around the world. Our department is deeply appreciative that our field of study has been added to the family of Nemmers Prizes, and we look forward to honoring and interacting with leading Earth

scientists who have made transformative contributions to understanding our planet."

The article also featured a quote from Dan Linzer, Northwestern's provost: "I am extremely pleased that the growth of the Nemmers endowment allows us to add a fifth prize. By recognizing outstanding individuals conducting research in the Earth sciences, we are also recognizing Northwestern's commitment to this essential field and the importance of this work for the sustainability of the Earth."

The solicitation for nominations will appear in early 2017 and the first recipient of the Nemmers Prize in Earth Sciences will take up residence on the Northwestern campus sometime during the 2018-19 academic year.

Meet Our New Research Staff!

Dr. Mitchell Barklage has a passion for teaching, research, and working with students. He is looking forward to applying his expertise in the areas of shallow/applied geophysics, active-source seismology, and geoscience computing to promote the professional development of EPS grads. Mitch obtained his Ph.D. in seismology at Washington University in St. Louis, then worked for 6 years in the seismic acquisition industry, where he developed novel ways of acquiring and analyzing seismic data for subsurface imaging from wireless "Nodal" seismometers. Since starting this Fall, Mitch has supported the Northwestern University seismic network with field installations and also our public seismic kiosk in the F-wing atrium, taught Generic Mapping Tools (GMT) to students in two different courses, and provided targeted research support such as working with the Jacobsen Group on questions at the interface of mineral physics and seismology. Furthermore, Mitch is deeply involved in the recently funded rejuvenation of the hardware and software in the EPS Computing Laboratory, used for teaching experiential courses in seismology and climate change. In other words, Mitch has already become indispensable.

Dr. Andrew Masterson arrives with a wealth of experience in sulfur and carbon stable isotope geochemistry, high-precision isotope methodologies, and analytical chemistry, based on his time managing labs at the Harvard and the University of Maryland, followed by his PhD thesis at Harvard,



"Multiple Sulfur Isotope Applications in Diagenetic Models and Geochemical Proxy Records." Lab PI Maggie Osburn shares with us: "Andy is the ideal person to lead our stable isotope facility. I am continually impressed by his intellect, industriousness, and natural mechanical ability. In the three short months since he has joined us he has produced data from all four peripheral instruments and greatly improved other aspects of lab functionality. I think it is safe to say that we can expect a bright future for IRMS under his guidance." Furthermore, Andy's natural ability for teaching and mentoring is already being exercised with training students towards being independent analysts in the stable isotope lab. Should you need stable isotope analyses in support of your professional activities beyond Northwestern University, then consider contacting Andy to benefit from his expertise and our fully equipped lab capable of H, C, O, N and S isotopic analysis in a range of earth materials.

EPS Field Trips and Excursions

EARTH 331 Field Trip- Field Problems in Sedimentary Geology



We continued a long department tradition this Fall 2016 with our epic 3+ week field course through Colorado and Utah, exploring sedimentary sequences ranging from Pennsylvanian to Late Cretaceous. Our group of 5 undergrads, 3 PhD students, and Trish Beddows followed Brad Sageman's lead, with a caravan of 2 well-packed vans and a 4x4 truck. The trip offered a first experience in both camping and outcrop work to a number of our students.

Brad shares with us, that "the member of our department who consistently gets the most awards for teaching is **The Field**. There is no substitute for getting our students on the outcrop and having them engage in direct observation and measurement of rocks." The value of time in the field is echoed in the comments of some of our recent alumni, with the majority of the respondents to a survey on the undergraduate experience commenting on the pivotal role that the field course played in their development as Earth Scientists. One Alum shared with us that "field trips were essential. Understanding textbook concepts alone is useless if you can't figure out how to recognize and apply them in the field. Trips to the UP, Baraboo, and Colorado/Utah were important for me to put classroom learning into a real-world context and scale."

The EARTH331 trip is made possible through the generous support of our alumni, contributions from the Ken Cohen Family Fund, and a welcome stop at the Johnson Farm in Iowa.

The History of the Baraboo Field Trip

The area around Baraboo, Wisconsin offers some of the best geological exposures to be found for thousands of miles in the central U.S., and it has been a mecca for geology field trips since time immemorial. The Department of Earth and Planetary Sciences is no exception, and we have a long history of Baraboo field trips, even going back to the days before Sloss and Schlanger.

Much of our knowledge about the history comes from oral tradition – the stories Larry Sloss shared before he passed away in 1996. For many years the field trip was part of an introductory course in geology open to non-majors. Based on the records from a church in Fort Atkinson, Wisconsin, where the Northwestern group stopped for Friday evening dinner on the way north, our trip has run since the early 1900's. Why the regular stop there? Sloss informed us that they went by train in those early days, and there was either a stop or terminus in that town. Thus, a chicken dinner was enjoyed in the church hall.

By 1981 the associated course was entitled "Origin of Mountains" and taught by a succession of faculty including Finley Bishop, Donna Jurdy, Sy Schlanger, and Tim Whitten. By the early 1990's the name had shifted to "Surface Processes" and was taught by Susan Agar or Ray Russo. Around the year 2000, the course was re-defined as a 200-level introductory class for department majors and taught by Brad Sageman as EARTH 201 – Surface Processes. When Brad became department chair in 2005 he passed the course to Andy Jacobson, who changed the name to EARTH 201 – Earth Systems Revealed based on a new textbook he had chosen for the class. At that point the department took

responsibility for funding the trip under the assumption that the weekend field experience was most properly aimed at aspiring earth science majors.

The enrollment size in this class has always been limited by bus capacity for the Baraboo field trip – somewhere around 45 students. This is about as many as manageable on the small outcrops and road cuts of Baraboo. But almost all who have had the experience share a similar appreciation for the excellent geology of the area. And many students describe EARTH 201 as one of the best courses they have had at Northwestern because of the unique off campus experience in experiential learning.

So we ask you, Alumni – did you participate in a department trip to Baraboo? What do you recall? Does anybody have photos? We will follow up and check with the church in Ft. Atkinson to see if they have any pictures from the early days.

Please send your responses to earth@northwestern.edu.



Other Department Happenings

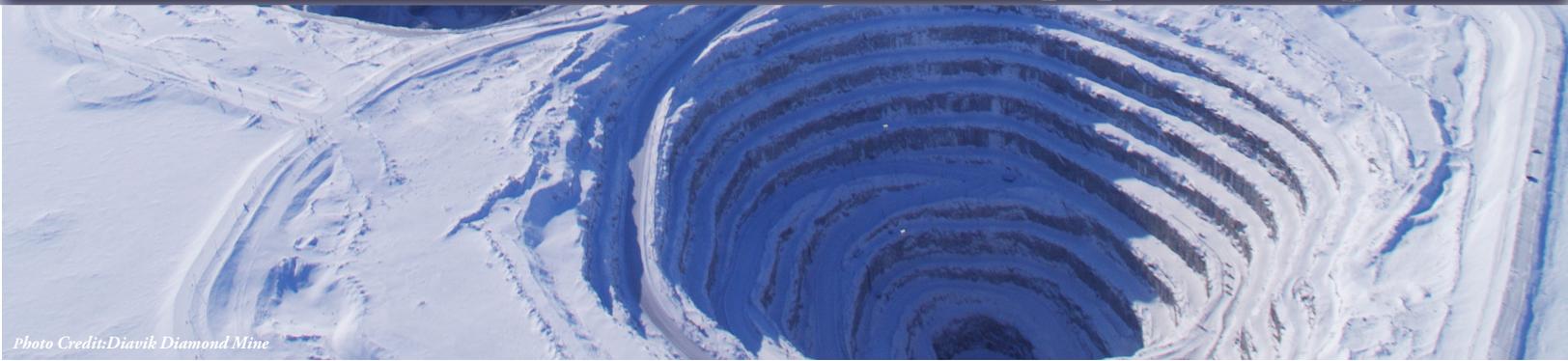


Photo Credit: Diavik Diamond Mine



In June, Steve Jacobsen visited the Diavik Diamond Mine, about 200 miles north of Yellowknife, NWT. An aerial perspective of the mine is featured in the banner above. His research on mineral inclusions found in diamonds reveals clues about the recycling of volatiles such as water and carbon dioxide in the deep mantle.

The Northwestern Seismic Network

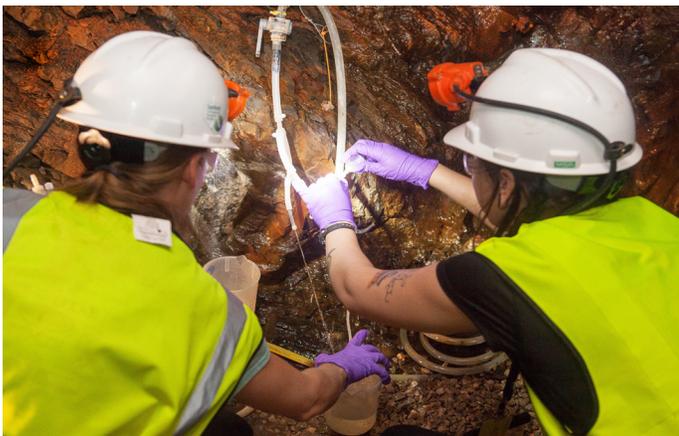
Over the past few summers, we have maintained and expanded our seismic network with an additional field station at a suburban Chicago quarry. The second field station at the Lake County Ryerson Forest Preserve was adopted from Earthscope. Our third station is located on campus and used for education and public outreach. The Northwestern Seismic Network has been instrumental in locating and characterizing seismicity in Illinois.



Trevor Bollmann and Emile Okal survey the environment in the quarry.



Emily Wolin teaches Hao Zhang how to service and maintain a seismic station.



Brittany Kruger (left) and Caitlin Casar (right) sample fluids from a borehole 1,460 meters deep at the Sanford Underground Research Facility in Lead, South Dakota.

The fluids host lithotrophic microbial communities of interest to the NASA Astrobiology Institute "Life Underground" research team whose objectives include characterizing deep subsurface life in extraterrestrial analogue environments.



On December 17, 2016, a group of NU EPS faculty, students, alumni, and friends took a day off from the American Geophysical Union meeting and toured the San Andreas Fault at Point Reyes National Seashore, north of San Francisco.

This area is near the historic rupture of the San Andreas Fault observed after the 1906 San Francisco earthquake. They walked a trail to a reconstructed historic fence offset by the Fault in 1906. The original fence at this location was offset about 18 feet.

GRADUATION SPOTLIGHT

2016

This year saw the departure of many students from Earth and Planetary Sciences. Our department graduation reception was held on June 17th, 2016 and recognized our graduates and their families.

2016 Student Awards:

Grace Andrews,
Marion Sloss Award for
Outstanding Graduate
Teaching Assistant

**Grace Andrews and
Edward Brooks**, Horace A.
Scott Award for Excellence
in Graduate Research

**Dana Beecher Johnson
and Tyler Kukla**,
Seymour Schlanger
Undergraduate Earth
Science Award

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

B.A./B.S. Undergraduates:

B.A. Students:

Erik Baker
Steve Brand
Rui Chen
Marine Coste
Liz Fillion
Matt Giuffre
Dana Johnson
Tyler Kukla
Victoria Nelson
Jiayue Peng
David Rice
Josh Williams

B.S. Students:

Victoria Nelson
Jiayue Peng

Ph.D. Students and Their Dissertation Titles:

Laurel Childress, *The Active
Margin Carbon Cycle: Influences of
Climate and Tectonics in Variable
Spatial and Temporal Records*

Renee Apphia French, *Using
Orbiter Spacecraft Data to
Characterize Small-scale Surface
Features on the Moon and
Constrain Geophysical Properties of
the Martian Crust*

Ashley Gilliam, *Titan Through
Time: Evolution of Titan's
Atmosphere and its Hydrocarbon
Cycle on the Surface*

Brian Kristall, *Marine Sulfur and
Strontium Cycling During the
Transition from a Cool to Warm
Greenhouse in the Early Cretaceous*

Gregory O. Lehn, *Advances in
Calcium Isotope Geochemistry:
Method Development and
Application in a Multi-Proxy
Investigation of Alaskan Arctic
Watersheds*

Joshua Paul Townsend, *The
Effects of Hydrogen on the Physical
Properties of Earth Materials and
Equations of State*

Emily Lynne Wolin, *Structure,
Seismicity, and Instrumentation of
Stable North American Lithosphere
Properties of Earth Materials and
Thermodynamic Equations of State*

**This year, the
Department of Earth
and Planetary Sciences
welcomed its largest
group ever of incoming
graduate students.**

Caitlin Casar will be
studying geobiology of
extreme environments with
her advisor, Dr. Osburn. She
received her M.S. in Earth
& Environmental Sciences
from the University of Illinois
at Chicago, and her B.S. in
Geology from East Carolina
University.

Howard Chen will be
studying the atmospheres
and climate of Earth and
Earth-like planets with his
advisor Dr. Horton. He joins
us from Boston University,
where he received a B.A. in
Physics.

Reece Elling will be
studying the geophysics
of the Midcontinent Rift in

central North America with
his advisor Dr. Stein. He
received a B.S. in Geology
from Grand Valley State
University.

Phylindia Gant will be
studying the abundance
and speciation of water
in minerals, meteorites
and silicate glasses with
her advisor Dr. Jacobsen.
She received a B.S. in
Interdisciplinary Science
from Purdue University and
an M.A. in Environmental
Sciences from the University
of Virginia.

Gabby Kitch will be
studying the impact of
past climate change on
the carbon cycle using
geochemical tools with her
advisor Dr. Jacobson. She
joins us from Washington
Lee University, where she
received a B.S. in Geology.

Laura Larocca will be
studying climate change in

the arctic with her advisor Dr.
Axford. She received a B.F.A.
from New York University
and an M.S. in Earth and
Atmospheric Sciences from
Hunter College.

Annie Nelson will be
studying long term controls
on Earth's climate with her
advisor Dr. Jacobson. She
received a B.S. in Geology
from Union College.

Boris Roesler will be
studying the distributions
and focal mechanisms
of earthquakes with his
advisor Dr. van der Lee. Boris
has two undergraduate
degrees, one in Physics
and one Geophysics from
Universidad de Colima
and Ludwig-Maximilians-
Universität in Munich,
respectively.

Leah Salditch will be
studying macroseismology,
earthquakes and tectonics
with her advisor Dr. Stein.

She has two undergraduate
degrees in Liberal Arts
and Anthropology, and
completed an M.S. at the
University of Texas in Dallas.

Yuxi Suo will be
studying the impacts of
anthropogenic climate
change with her advisor
Dr. Horton. Yuxi comes to
us from the University of
California at Los Angeles,
where she received her
International Undergraduate
Degree in Geography and
Environmental Studies.

Jacoya Thompson will be
studying the relationship
between long-period noise,
soil type, temperature
and atmospheric pressure
in seismic data with her
advisor Dr. van der Lee. She
joins us from Fayetteville
State University, where
she received both a B.S. in
Computer Sciences and an
M.S. in Mathematics.

FACULTY HIGHLIGHTS

YARROW AXFORD's lab group made its first expedition to southernmost Greenland this past summer, funded by an NSF-CAREER award. Grad students Jamie McFarlin and Everett Lasher (undaunted by warnings about rabid foxes and ravenous mosquitoes) recovered Holocene sediment cores from four high-elevation lakes, which they will use to reconstruct Holocene and recent changes in atmospheric circulation and hydroclimate. Jamie's work, co-advised by Maggie Osburn, has won her two competitive grants from NSF: a Graduate Research Fellowship and a Doctoral Dissertation Research Improvement grant. Undergrads Karalyn Berman, Peter Kotecki and Basia Gawin also conducted independent research in the Quaternary Sediment Lab. New graduate student Laura Larocca will investigate the Holocene history of mountain glaciers in Greenland, beginning with next summer's expedition to glacier-fed lakes. Yarrow continues to teach courses on climate and paleoclimate and is planning a new course on science communication. A personal highlight in 2016 was publishing a column on women in science in the journal *Science*.

With a new NSF grant, **TRISH BEDDOWS** continues to provide earth science context for archeological exploration in the Yucatan Peninsula. This new effort at the Maritime Maya site "Vista Alegre" aims to assess sea level control on coastal fresh groundwater discharges over the Holocene. This project is an extension of Trish's mini-Critical Zone Observatory already counting with 40+ stations for climate, water-level, temperature profiles, and cave flow, all using the "Cave Pearl" open source data logging platform (see www.youtube.com/watch?v=kJGhwMB4eew). The July field season included 3 weeks with undergraduate Peter Carlin whose measured field permeability over a range of carbonate facies. The summer culminated with 26 rewarding days of field co-teaching for the powerful Sedimentology Field Problems led by Brad Sageman. 2016 publications included a geoarcheology paper in *Wiley Reviews – Water*, and a study on the stable isotopic lapse rate of vadose drip waters in a transect of caves on Vancouver Island published in *GCA*.

CRAIG BINA spent the 2015-16 academic year serving as Acting Dean of The Graduate School and Acting Associate Provost for Graduate Education. After speaking at the Fall Meeting of the American Geophysical Union (AGU), he joined colleagues in examining igneous and metamorphic rocks associated with Farallon subduction. Despite administrative demands, he managed to undertake two overseas research

trips in the spring of 2016. In March, he returned to Charles University in Prague, continuing research collaborations with Czech colleagues in geodynamics and seismology. Later, in May, he attended the annual meeting of the Japan Geoscience Union (JpGU) in Chiba near Tokyo. This fall he happily returned to teaching the ISP geophysics course. Meanwhile, he serves as AGU's representative for solid-Earth sciences on the Program Committee of the first JpGU-AGU Joint Meeting, planned for May 2017 in Chiba.

NEAL BLAIR's research has involved studying the sources and fates of eroded sediments and carbon in response to land use and climate change as part of the Intensively Managed Landscapes - Critical Zone Observatory (CZO) supported by NSF. The objective of the research is to understand how landscape engineering for agriculture has altered fundamental biogeochemical processes, and how future climate change will impact the system. The study involves both riverine and reservoir C-biogeochemistry including observations of C-sequestration and methane emissions. Professor Blair traveled to the Goldschmidt Conference in Yokohama this summer to present results from the CZO study, organized a session on C-erosion in the Critical Zone at the same conference, and participated in a cross-CZO workshop on microbial ecology in Montreal.

The start of year two in **DANIEL HORTON's** Climate Change Research Group has seen the brainpower arrive. Dan's first graduate students, Howard Chen and Yuxi Suo, began their Northwestern careers in September, and undergraduate researchers, Christopher Callahan and Spencer Weiser, have joined up to study climate change and its impacts. In the classroom, Dan designed and taught two new courses this spring, an upper level course on Earth System Modeling and a freshman-writing seminar, "Sustainability and Social Justice." A highlight of the latter course was a fieldtrip to the Little Village neighborhood of Chicago, to learn about citizens' attempts to shutter the local coal-fired power plant. On the research front, investigations into recent atmospheric circulation patterns continues with the publication of collaborative work on the California drought and recent extreme cold east coast US winters. Lastly, the demand for climate science education and outreach led to several guest lectures in Northwestern's McCormick, Medill, Pritzker, and Weinberg classrooms, in addition to a seminar on air quality in developing nations at the Carnegie Endowment for International Peace in Washington D.C.



MATT HURTGEN's research group utilizes geochemical signatures preserved in sedimentary rocks to reconstruct the chemical evolution of Earth's oceans and atmosphere over the past 1 billion years. In January 2016, Maya Gomes (Ph.D. 2014), Professor Brad Sageman and Hurtgen published a paper in *Paleoceanography* presenting high-resolution carbon and sulfur isotope records through oceanic anoxic events OAE1a and OAE2. Graduate student Brian Kristall successfully defended his Ph.D. in November 2016. Brian worked to better constrain the couplings and feedbacks that were responsible for regulating the biogeochemical cycles of sulfur and strontium during the Early Cretaceous.

STEVE JACOBSEN was promoted to full professor Fall 2016. This year, he and co-workers from Canada and Germany discovered a mineral inclusion trapped inside a diamond from Juina, Brazil, containing signatures of water from 1000 km depth. The work, published in *Lithos* and covered widely in the media, is the deepest evidence for water in the Earth, implying a global-scale water cycle operating over geologic time. While normally found in his mineral physics laboratory, this year Steve enjoyed a chance to be in the field during a geology trip to the Slave Craton, after which he visited the Diavik diamond mine in the Barren Lands. His group now has many more diamonds to crush in search of clues about the composition of the deep mantle. At Northwestern, Jacobsen created a new course for non-majors, EARTH-101: Earth Science for the 21st Century, where he gives Ted Talk style lectures on geology, energy, and climate through the lens of current events. Fall 2016, enrollment in 101 surpassed 450, possibly making it biggest class on campus! While not doing that, Steve was having a blast with his three girls, now 5, 11, and 14. In June, Steve Jacobsen visited the Diavik Diamond Mine, about 200 miles north of Yellowknife, NWT. His research on mineral inclusions found in diamonds reveals clues about the recycling of volatiles such as water and carbon dioxide in the deep mantle

ANDY JACOBSON welcomes two new graduate students, Gabby Kitch and Annie Nelson. Gabby plans to develop methodology for the analysis of B isotopes to support deep time ocean acidification studies, while Annie will take the lead on Jacobson's recently funded NSF project to examine the Ca and Sr isotope geochemistry of basalt weathering in Iceland. During the summer of 2016, Greg Lehn defended his dissertation and conducted fieldwork in the Canadian Arctic Archipelago, as part of a collaborative NSF project between Jacobson and investigators at the University of Washington. Graduate student Grace Andrews published an article focusing on the stable Sr isotope geochemistry of rivers draining Fiordland New Zealand (Andrews et al., 2016). She plans to defend her dissertation during the Spring of 2017 but before then will begin a post-doc at the

University of Southampton. Dr. Alain Potrel continues to provide essential support for the Radiogenic Isotope Geochemistry Clean Laboratory.

DONNA JURDY's research focuses on tectonic activity on terrestrial planets and outer satellites. Donna continues her work on topographic features on Venus, recently comparing its mountain belts to different possible analogues on Earth, also working with the SPREE project using archived seismic reflection data to provide insight into models for tectonic evolution of the North American Mid-Continent Rift. Having completed her term of service on the Board of the Association for Women Geoscientists (AWG), she continues to chair of their Professional Excellence Award, an award she initially proposed. Also, she will concentrate on building an endowment for the AWG Chrysalis award. She regularly serves on NASA, NSF and USRA panels such as Postdoctoral Fellowships, enabling her to actively advise department students and others on their fellowship applications.

GIL KLAPPER continues teaching Earth System History (203; aka Historical Geology) in the fall quarter, 2016. His comprehensive study of the classic western New York stratigraphic sequence, titled "Frasnian Late Devonian conodont biostratigraphy in New York: graphic correlation and taxonomy" was published by the *Journal of Paleontology* in August 2016. This was based on many years of research with colleague Bill Kirchgasser of SUNY Potsdam, who with the late Michael House, professor at Hull and Southampton universities, published an outstanding monograph on the ammonoid cephalopods from the same stratigraphic sections in 2008. For biostratigraphy, these are the two most important fossil groups in the Devonian.

EMILE OKAL retired as of September 1st, 2016, from formal teaching, and continues his research and mentoring of graduate students under Emeritus status. He was invited as a keynote speaker to the AAAS in Washington, D.C. in February, and an Observer to the 2016 IOWAVE Tsunami drill in Padang, Indonesia in September.

For the last three years **ABRAHAM LERMAN**'s research continued to be in the field of the biogeochemical cycles of the past and present, and it expanded into Planetary Science, in advising Ashley Gilliam (Ph.D. as of November 2016) on her Doctoral Dissertation on Titan, the largest satellite of Saturn with an atmosphere similar to that of the Earth and made of methane (CH₄) and nitrogen (N₂). This research resulted in the estimation of the cooling time of Titan from its accretion temperature of 300-350 K to the present-day 94 K; derivation of the escape rate of methane from Titan's atmosphere, based on the Maxwell-Boltzmann distribution of molecular velocities; history of the formation of ethane (C₂H₆) by the photolysis of methane, its condensation, and accumulation as liquid on the surface and subsurface

of Titan; the formation of erosional channels on Titan was modeled as a combination of dissolution of the crustal water ice by concentrated solution of ammonium sulfate and mechanical erosion by liquid ammonia and ethane, the dissolution and erosion processes occurring at different periods of Titan's cooling history. In the field of Terrestrial Geochemistry, Abe Lerman and Fred Mackenzie, continuing their long-time collaboration, completed an invited article *Carbonate Minerals and the CO₂-Carbonic Acid System* for Encyclopedia of Geochemistry, edited by William M. White and to be published by Springer

MAGGIE OSBURN's Lab is growing and pursuing a diverse set of research projects including work on deep subsurface geobiology, Greenland paleoclimate, and lipid isotope systematics. Caitlin Casar joined the lab, bringing her considerable expertise to understanding and culturing subsurface microorganisms. This year Maggie's team established a deep mine microbial observatory (DeMMO) to monitor the composition and activity of microbes living deep underground. Jamie McFarlin continues her work in Greenland in collaboration with Prof. Yarrow Axford and was funded this year through an NSF DDRI grant. Their fieldwork this year included trips to the former Homestake Gold Mine in South Dakota, Yellowstone NP, Mammoth Cave, NP, and Greenland. Undergraduates continue to play a big role in the Osburn Lab with Dana Johnston completing her thesis on carbonate microbialites, Jordan Todes working on lipid compositions of subsurface organisms, and a new undergraduate Hannah Dion-Kirschner working on the leaf wax composition of high latitude plants. Recent publications include work in *Frontiers* on hydrogen isotope systematics of anaerobes and *IJSEM* characterizing a new hyperthermophilic archaeon.

BRAD SAGEMAN co-taught his advanced stratigraphy field course in the late summer of 2016 with assistant chair Trish Beaddows, and then stayed in Colorado for the annual GSA meeting, where he ran a pre-meeting field trip to the classic Cretaceous outcrops of Pueblo CO and co-chaired a topical session with department colleague Matt Hurtgen in honor of the scientific contributions of Michael Arthur. Arthur's connection to our the department runs deep as he was a close colleague of departed and beloved colleague, Sy Schlanger, Sageman's post-doc advisor, and Hurtgen's PhD. advisor. The session was a great success. Following the GSA meeting, Brad was an invited speaker at the NSF EarthTime workshop held at the USGS in Denver (along with colleague and department alumnus, Steve Meyers, an associate professor at UW-Madison). Since returning to Evanston, Brad has been working on administrative tasks for the department, the Institute for Sustainability and Energy at

Northwestern (ISEN), and the Sustainability Council, which will be rolling out a campus sustainability plan before the end of this quarter. Brad has also been revising a co-authored manuscript for resubmission to *Nature* and had two other co-authored publications appear in the same issue of *Cretaceous Research*.

SETH STEIN has been elected President of the AGU's Natural Hazard Focus group. He is working with grad students Eddie Brooks and Leah Salditch, statistics Professor Bruce Spencer, and collaborators at other institutions on better assessing earthquake hazards. Because faults sometimes show clusters of earthquakes with relatively short times between them, separated by longer times without earthquakes, it looks like faults are smarter - in the sense of having better "memory" - than seismologists have generally assumed. Seth and collaborators a new model for the evolution of the Midcontinent Rift System, a 3000km long scar across North America which began to tear apart 1.1 billion years ago but failed to form a new ocean, and are using it for insights into how rifting has worked worldwide over time.

Over the last year, **SUZAN VAN DER LEE** worked with her colleagues from the P&A and EECS departments ramping up a new NSF-funded graduate training program in Data-Driven Discovery in Astrophysics and Geophysics (IDEAS). She also re-designed her Introduction to Scientific Computing course to be heavily python focused and largely self-paced, and revamped the Earth Science Computing Lab, in which the course is taught. This effort allowed for seven diverse interns to use the lab, working with Van der Lee and Okal, for summer research projects on topics centered on teleseismic delay time analysis, but ranging from seismic travel time curves for Pluto to the potential of deep earthquake recordings to detect high-attenuation regions in the mantle. Results from the multi-university SPRE Experiment that she coordinated are reaching the maturity required for publication, spearheaded this year by Hao Zhang's JGR paper on crustal structure. Hao finds that the Mid-Continent Rift is underplated all along its axis and that the direction of post-rift compression is the dominant factor governing the variations in the gravity anomaly along the rift. Hao has since moved to the University of Utah, where he is working with alumnus Keith Koper and others. Along with graduate students Vivian Tang and Boris Rösler, Van der Lee also began a collaboration with former MIT postdoc Kevin Chao, who is now a University Data Scholar at Northwestern.



GRAD STUDENT UPDATES



Grace Andrews published her findings on stable Sr isotopes as a biogeochemical tracer in New Zealand. She presented research on the subglacial carbon cycle of the Greenland Ice Sheet at AGU and research on stable Sr isotopes as a tracer of chemical weathering in Iceland at Goldschmidt, the latter for which she was awarded travel grants from both NSF and AWG. She also earned a teaching certification from Northwestern's Searle Center. She was honored to receive the department's Horace A. Scott Graduate Award for Outstanding Research as well as the Marion Sloss Award for Outstanding Graduate Teaching Assistant. In January, she will start a post-doc at the University of Southampton as part of the Leverhume Centre for Climate Change Mitigation and will defend her PhD shortly thereafter.

Trevor Bollmann, currently a remote student, works at the Chevron office in Covington, Louisiana while he finishes the writing of his thesis on P-wave tomography of the Midcontinent Rift. At Chevron he is on the Geophysical Services Team supporting work on deepwater assets by inverting seismic datasets for rock properties.

Eddie Brooks continues to work on investigating the performance of earthquake hazard maps. He presented his work last year in Vienna at EGU, and will present at the upcoming AGU and SSA conferences later this academic year. He has been recognized with the award of the Horace A. Scott Award for Outstanding Research, and a fellowship with the Institute for Policy Research. Eddie spent this past summer working in Houston as an intern at Chevron, where he studied machine learning and image recognition techniques.

Matt Jones is in his fourth year in the EPS PhD program. His research efforts in stratigraphy and sedimentary geology focus on geochemical lab work, drafting scientific manuscripts for publication, serving as a teaching assistant for Earth 201, and presenting research results at geoscience conferences. He spent January-March 2016 visiting Durham University (UK) to perform high precision rhenium-osmium (Re-Os) isotope analyses on core samples spanning a major ocean anoxic event (OAE). Re-Os measurements track changes in global volcanic activity through time. New results suggest that the onset of large igneous province volcanism during the initiation of Late Cretaceous OAE2 resulted in a rapid change in carbonate sedimentation patterns possibly related to altered seawater chemistry from increased CO₂. His research findings were presented at the 2016 Geologic Society of America's (GSA) annual meeting in Denver, CO and at a Society for Sedimentary Geology (SEPM) conference on OAEs and hydrocarbon source rock development in Austin, TX.

Satbuyl Kim, a visiting student, currently focuses on an analysis of tsunami forerunner waves using the beam-forming method, which is able to detect the direction and velocity of waves, with Prof. Okal. When large earthquakes occur on the eastern coasts of Japan, they usually generate large tsunamis, and sometimes they reach the Korean peninsula several hours later. However, at some tide gauge stations in Korea, there are tsunami records that are observed as soon as a large earthquake occurs. She is working on understanding this phenomenon. She also published her first paper in March 2016, titled "The Nankai Trough earthquake tsunamis in Korea: Numerical studies of the 1707 Hwei earthquake and physics-based scenarios," in *Earth, Planets and Space*.

Everett Lasher is continuing his research on the Holocene climate history of Greenland's west coast. He recently completed his 4th field season in Greenland, collecting several new sediment cores for the Quaternary Science Lab. Prior to field work, Everett traveled to the University of Southampton for a workshop focused on the state of isotope-based lake sediment proxies. He continues work on inferring climate change by measuring oxygen isotopes archived in lacustrine organic material.

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 called the transition zone. He has recently completed a yearlong visiting student fellowship at Los Alamos National Laboratory (LANL), working with the shock and detonation physics group. At LANL he developed *in situ* measurement capabilities to further the goal of understanding the behavior of materials at high pressures and high temperatures. Recently, he presented the progress and results of these projects at the 2015 CDAC Review and the 2015 AGU conference. John also presented LANL's newly developed measurement capabilities at this year's COMPRES meeting.

Jamie McFarlin continues her work on records of interglacial climate in Greenland using biologic and geochemical proxies. She spent the summer in south Greenland where she collected sediment cores for new work to examine the late Holocene in high resolution. This past year she presented a poster at AGU on some of the preliminary findings of her research in northwest Greenland and is currently in the process of writing these findings for publication. Jamie, along with her advisors Yarrow Axford and Maggie Osburn, was recently awarded an NSF DPRI grant for her work on improving the understanding of hydrogen isotopes in sedimentary plant lipids as a hydrologic proxy in the Arctic.

Jamie also continues to work with the Medill School of Journalism on science communication and outreach.

Fifth-year student **Emiliano Monroy-Ríos** is interested in the water-rock interactions and geochemistry of coastal carbonate aquifers. He employs cave diving techniques to get access to the geology of the marvelous underwater cave systems in the Yucatan Peninsula in order to collect the samples needed to perform geochemical analyses to obtain results that will support his research. Recently, he is developing a hydrogeothermal model for the formation of the Chicxulub Ring of Cenotes (CROC), providing mechanisms linking geochemistry and hydrogeology. Also, he has been supporting as a guest-speaker a number of Physical Sciences classes in different City Colleges of Chicago.

Fei Qin is a visiting graduate student from Peking University working with Prof. Steven Jacobsen. She is focusing on structural stabilities and physical properties of the Earth's mantle minerals in the subducted slabs to better understand the hydration state of the Earth. She is currently working on some hydrous minerals at simultaneously high pressure and high temperature conditions. To study these Fei has already conducted a series of experiments at the Advanced Photon Source at Argonne National Laboratory by using Synchrotron X-ray diffraction, Brillouin Light scattering as well as Raman spectroscopy. This past June she published her paper titled "High-pressure behavior of natural single-crystal epidote and clinozoisite up to 40 GPa" in *Physics and Chemistry of Minerals*.

Amir Salaree is working on the distribution of tsunami amplitudes and dominant periods due to earthquake source and bathymetry variations. He is also working on the ambiguous sources of tsunamis at the Gulf of Kamchatka in 1923 and the Philippines in 1975.

Nooshin Saloor continues to work on earthquakes source parameters. She is working on extending the calculation of the slowness parameter in depth and distance. Nooshin has submitted

a paper in the *Geophysical Journal International* and presented a poster at the 2016 AGU conference.

Vivian Tang is currently investigating the deep mantle structure beneath East Asia by "lithosphere-corrected" body-wave tomography. She is also working with a postdoctoral scholar at Northwestern to use USArray data to find tectonic tremors in North America. She has published a paper on seismological evidence for changing velocity gradients in the topmost outer core, and has presented posters at the national AGU and SEDI conferences. She has also been recognized with an IDEAS fellowship award for the 2016 academic year.

Fei Wang is working on a computer program that collects literature results from mineral physics experiments and theory to build an elasticity database, which is then used in the modeling of the effects of mineralogy, temperature, iron content, and water content, on the seismic wave speeds and their discontinuity structures in the Earth's mantle.

Jiuyuan Wang, a second-year Ph.D. student, is currently working on a Permian-Triassic project that integrates calcium isotope, radiogenic and stable strontium isotopes to try to better understand the ocean chemistry change and global carbon cycle perturbation across the most severe mass extinction in the Earth's history. He is also interested in applying stable strontium isotopes in other major events, such as Neoproterozoic snowball earth and Cretaceous oceanic anoxic event. In addition, he is collaborating with researchers in Penn State, Oak Ridge National Laboratory and China on a shale-gas related project focusing on the pore structure evolution during shale diagenesis process. He also enjoys public services, including presidency of the Chinese Students and Scholars Association, Northwestern's largest international student group, and student board membership in the China University of Petroleum.

Michelle Wenz currently studies diamond inclusions to better understand the hydration state of the Earth's mantle. She currently has a set of 61 diamonds from Juina Brazil (courtesy of Graham Pearson) each containing multiple inclusions. This locality is a super-deep source known for bringing up minerals from the transition zone (410 -660 km) and top of the lower mantle. To study these inclusions Michelle uses both Raman spectroscopy as well as X-ray diffraction techniques as the latter can reveal information on inclusion pressures. She has applied for beam time on an X-ray diffraction line at the Advanced Photon Source at Argonne National Lab. This past June Michelle attended the International Diamond School in Alberta, Canada where she presented a poster on the formation and evolution of diamonds, work done with Steve Jacobsen and Tiziana Boffa Ballaran also in collaboration with William Basset, Elise Skawold and John Koivula.

Michael Witek is continuing his work on estimating the structure of the East Asian lithosphere by inverting measurements of Rayleigh wave group velocities from ambient noise cross-correlations. He has finished several preliminary models and will be preparing a paper for submission soon. Michael has also been working on modifying and making additions to Prof. Suzan van der Lee's joint inversion code, which will allow researchers to simultaneously invert various seismic data in an effort to remove ambiguities that arise from using a single type of measurement to improve model resolution. In addition, Michael has been working on applying the energy reassignment method to ambient seismic noise data collected from accelerometer stations in Korea to identify biases that may arise using traditional spectrogram measurement techniques. Michael has been applying for postdoctoral fellowships and hopes to graduate next year.



ALUMNI NEWS

Kim Adams, M.S. '09, and her husband Derek, who is also a Northwestern alum, recently celebrated their 10 year wedding anniversary. Their son, Clark will be turning four years old in March and is a spunky and inquisitive young boy. Her two beautiful baby girls, Evelyn and Eleanor, recently turned one. Congratulations, Adams family!



Heather Bedle, Ph.D. '08, worked for 8 years at Chevron in both development geology and geophysics in the Gulf of Mexico, before moving to Houston to join the Reservoir Properties Team. This past summer, Heather changed careers, joining the University of Houston as an Instructional Assistant Professor, teaching graduate courses in petroleum geophysics including 3D Seismic Exploration, Advanced 3D Seismic Workflows, and Reservoir Characterization with Seismic Attributes.

Jeremy Cooper, B.A. ES '94, is a founder and partner of Cooper & Cooper Real Estate. Previously, Jeremy served as a Senior Associate for Bank of America Securities' Investment Banking Division. He also worked for several years as a television meteorologist for ABS, FOX, and NBC.

Kathleen Johnson, Ph.D. '90, is a Staff R&D Scientist working with the Spectral Sciences Research Team at DigitalGlobe. Primarily she works on applying 16-band (VNIR/SWIR) WorldView-3 imagery to geological projects involving remote sensing applications to volcanology and economic geology. She also works on Trees Species Typing and various other Forestry Projects, and was recently assigned to work with the Jane Goodall Institute on chimpanzee habitat preservation and has a part-time assignment to the GBDX Platform Development Algorithm Testing Team.

Michael Laine, M.S. '78, recently retired from the Utah Geological Survey as a Project Geologist and Curator of the Utah Core Research Center.

Allegra Mayer, B.A. '13, is now a 3rd year PhD candidate in biogeochemistry in the Environmental Science Policy and Management Department at the University of California, Berkeley.

Nora Richter, B.A. '14, is now a 2nd year graduate student at Brown University Marine Biological Laboratory.

We congratulate **Kimberly Schramm**, Ph.D. '07, on her new job! Kimberly recently started work in Quality Control at the Albuquerque Seismo Lab.

Brian Shiro, B.A. '00, is a geophysicist currently working as a Seismic Network Manager at the Hawaiian Volcano Observatory (HVO). Prior to joining HVO, he worked for 10 years at the National Oceanic Atmospheric Administration's Pacific Tsunami Warning Center in Honolulu.

Emily Van Ark, B.A. '99, gave an impromptu quest lecture to Professor Seth Stein's Data Analysis class this fall, "What Can I Do With a Degree in Earth Science?" Emily is a Data Scientist in the Descriptive Analytics Group at Ford Motor Company. After teaching high school Physics in Ghana with the Peace Corps, Emily completed a Ph.D. in Marine Geophysics in the MIT-WHOI (Woods Hole Oceanographic Institution) Joint Program, worked as a business management consultant with the Boston Consulting Group, and taught high school physics in Michigan. Emily's favorite part of the Earth is the mantle and her favorite Ford vehicle is the C-Max Energi.



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