

Newsletter 2017-18

Department of

GEOSCIENCES



PennState
College of Earth
and Mineral Sciences

From the Department Head



Hi alums:

I hope this newsletter finds you in good health and spirits. It's been a very exciting and productive year in the department. In case the news hasn't reached you, Lee Kump was recently named the seventeenth dean of the College of Earth and Mineral Sciences. We are incredibly proud of Lee for this major honor and we know that the college will benefit greatly under his dedicated and sage leadership. Lee's vision and energy has left the department a much better place. I'm sure all of the faculty will join me in thanking him for a job very well done. I've just re-stepped into the headship for a year as we conduct a national search for a new leader.

Lee plans to keep an active research program, but it's still a bittersweet time for many of us with the retirements of Mike Arthur and Terry Engelder, although we expect both of them to be in the department regularly. You can read more about Mike's and Terry's incredible careers in this issue, but needless to say we are going to miss these inspirational scientists. Mike "Black Shale" Arthur wrote the textbook on how ancient organic-rich rocks accumulated, and christened the field of chemostratigraphy. Terry "Marcellus" Engelder had one of the most productive late careers on record with his discovery of fracturing patterns in the Marcellus Shale that helped pave the way for gas production in our state. It's been fun to watch the career paths of these two very different scientists converge in recent years.

We also say goodbye to Don Voigt, who has been an anchor of our glaciology field programs for the last twenty years. Don had a multi-year streak of spending Christmas near the South Pole! Don has also helped with departmental operations. He plans on retiring from the latter duties but still helping out when field programs need him.

Finally, we say farewell to Tina Vancas, who served as department manager for the last six years. She skillfully made the operation of the front office first class, super customer friendly, and efficient. Tina assembled the most incredible group of staff I've ever seen in an academic setting, led them by example, working hard but also having fun along the way. Behind the scenes, Tina revolutionized our systems and expertly maximized our budget, allowing us to expand programs and start new ones. Tina left the department a much, much better place than when she arrived.

We welcome new faculty member Julie Cosmidis. Julie is a biogeochemist whose work focuses on how microbes control the formation of minerals in fluids and sediments. Julie comes to us from the University of Colorado where she was a postdoc, and I have to say she fits perfectly in our program. We also welcome Brandi Kamermans from the University of Minnesota. Brandi holds the inaugural Distinguished Postdoctoral Fellowship and her work concerns microbe-mineral interactions in aquatic environments. As you can figure out, Brandi will be working with Julie along with Jenn Macalady. Finally, we welcome Amy Homan, our new department manager. Amy comes to us from the Department of Physics where she was praised for her energy, experience, and her ability to foster teamwork. Amy is a long-time resident of Penns Valley.

I'm always in awe of our students and the energy, dedication, and professionalism they bring to the program, but I have to say that our current group has gone out of their way to impress us! Our Association of Woman Geoscientists group of graduate and some undergraduate students came together to organize WE ARE for Science, a group that advocates for strong science policy, works to improve the dissemination of science among the general population, and secure a diverse science workforce. The group attended the March for Science in Washington, DC. in April. You can read more about them later in the issue. I predict a superb future for these inspirational students!

And speaking of superb, I've not seen as talented and dedicated a group of departmental staff in my thirty years in academia! Our staff work quietly and enthusiastically to truly make the department a better place!

I hope you enjoy this newsletter! Please send along your news and if you are in the State College area, please stop by for a visit.

Happy holidays to all of you. With best wishes,

A handwritten signature in black ink that reads "T J Bralower".

Tim Bralower

The Geosciences Newsletter is a publication of the Department of Geosciences in the College of Earth and Mineral Sciences at Penn State

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Penn State graduate student selected for NASA astronaut program



Zena Cardman, a doctoral student in geosciences, was named to NASA's 2017 astronaut class on June 7. Image: NASA

Zena Cardman's career has taken her to some of the most extreme and remote places on Earth. Her new job could send her even farther.

Cardman, a doctoral student in geosciences, was named a member of NASA's 2017 class of astronauts on Wednesday, June 7, 2017. Vice President Mike Pence joined NASA officials in introducing the twelve men and women during a ceremony at the Johnson Space Center in Houston.

"I am beyond humbled and proud to be a part of our space program, and in the company of this new class of astronauts," said Cardman. "It's such a diverse group, and I'm thrilled to join my experience in microbiology and field research with the test pilots, medical doctors, engineers, and everyone else. I am so grateful for the mentors and colleagues who helped me along the way."

More than 18,300 people applied to the astronaut program, more than doubling the previous record of 8,000 set just before the dawn of the space shuttle era in 1978, according to NASA.

“We look forward to the energy and talent of these astronauts fueling our exciting future of discovery,” acting NASA Administrator Robert Lightfoot said. “Between expanding the crew on board the space station to conduct more research than ever before, and making preparations to send humans farther into space than we’ve ever been, we are going to keep them busy. These candidates are an important addition to the NASA family and the nation’s human spaceflight team.”

Cardman and the others are now considered astronaut candidates and started a two-year training program in August to become full astronauts and qualify for spaceflight missions.

They are joining at an exciting time for the space agency. Private companies are developing rockets that could someday take passengers to space, and NASA has plans to send future manned missions to Mars.

“We’re very excited that Zena is bringing Penn State’s long tradition of excellence in astrobiology into the U.S. space program,” said Jennifer Macalady, associate professor of geosciences and Cardman’s adviser.

Cardman is pursuing her doctorate in geosciences, where she studies microbe-rock interactions and what they can tell us about life on early Earth and beyond.

“I’m especially interested in life that lives in oddball environments on Earth, the extremophiles,” Cardman said after learning she was an astronaut finalist. “For me, that’s a good analogy for environments that might be habitable on another planet.”

Cardman said profound questions about the possibility of life on other planets has driven her research, including her current work studying the almost-alien lifeforms that grow on the walls of damp, remote caves that never see the light of day.

“Right now I’m studying cave slime,” she said. “That’s a really interesting environment. It’s totally dark all the time. Life there is not fueled by normal things we look outside our windows and see.”

Cardman, who hails from Williamsburg, Virginia, previously studied tiny organisms that thrive around hydrothermal vents deep in the ocean while pursuing her master’s degree at the University of North Carolina at Chapel Hill. She also received her bachelor’s degree in biology from North Carolina with minors in creative writing, chemistry, and marine sciences.

Beyond her degrees, Cardman brings a diverse set of experiences to the space program, from spending time in the engine room of a sailboat with the Sea Education Association to a field season in the stark isolation of the Palmer Long-Term Ecological Research station in Antarctica.

“From a NASA perspective, you want to be as versatile as possible,” she said. “You want to be a payload who’s worth your weight. You want to be able to be that scientific Swiss Army knife in the field.”

Cardman and the other astronaut candidates reported to the Johnson Space Center in August to begin training in spacecraft systems, spacewalking skills, teamwork and other skills.

They could then be assigned to missions ranging from working on the International Space Station to participating in deep space missions on NASA’s new Orion spacecraft, NASA said.

“It’s a really exciting time,” Cardman said. “Maybe more so than any in my lifetime. There is a lot of change happening, so we are not sure where this current class is going to end. That’s almost more exciting than knowing.”

Penn State has strong connections to NASA. Four Penn Staters have flown in space: alumni Paul Weitz, Robert Cenker, and Guion S. Bluford Jr. — the first African-American astronaut, who flew on the space shuttle Challenger in 1983 — and alumnus and Associate Professor of Kinesiology James Pawelczyk. In May, NASA awarded Penn State \$1.7 million as part of the NASA Aeronautics’ University Leadership Initiative.

Christopher House, professor of geosciences at Penn State, last year was chosen to join the Curiosity Mars rover science team. House is also director of Penn State’s Astrobiology Research Center and the NASA Pennsylvania Space Grant Consortium, which seeks to provide opportunities for Pennsylvanians to learn about and participate in NASA’s aeronautics and space programs by supporting and enhancing STEM education, research and outreach, programs.

by Matt Carroll

Penn State Geosciences



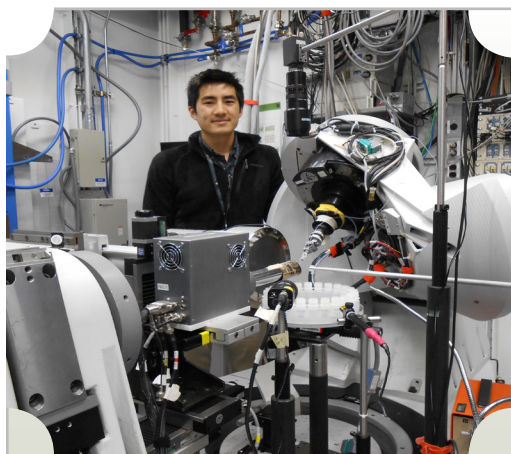
Bachelor's Degree Student: Safiya Alpheus

My relationship with geosciences started long before I ever had dreams of attending Penn State — it started, unwittingly, when I looked for fossils in my backyard at 7 years old. At the time, I had just learned about fossils and convinced myself that if I searched my backyard well enough I'd find a dinosaur fossil and become famous. The search went on for weeks but, to my dismay, I found neither fossil nor fame, but instead, a yearning to know more about the Earth and its treasures. Following my fossil quest, I made my first baking soda volcano and painted the globe, but it was only in high school that my fate was sealed in geosciences — after I learned about Alfred Wegener, continental drift, and plate tectonics there was no turning back.

Here at Penn State I've been able to grow in more ways than I ever would have imagined. Last summer, I participated in the AfricaArray Research Experience for Undergraduates and traveled to South Africa to conduct field research. My project was focused on looking at sulphur isotope fractionation in kimberlite xenoliths to gain insights into the subcontinental lithospheric mantle. After my field work, I conducted geochemical analyses on those xenoliths at the University of Maryland and even presented my work at a conference in New Orleans! Since then, I have been able to work under Dr. Maureen Feineman, studying the geochemical evolution of exhumed Alpine rocks; and with Drs. Kate Freeman and Sara Lincoln who study the effect of oil spills on microbial communities in the Gulf of Mexico.

Growing up in Trinidad and Tobago, I've gained an immense appreciation for culture that is echoed in my everyday life. When I'm not in class or the lab, I enjoy traveling, trying new foods, hiking, and playing the saxophone. I'm also the vice president of the Caribbean Student Association and a member of the Black Leadership Union.

I'm especially intrigued by Earth's isotopic record and the insights it gives about the evolution of both deep and surface Earth and hope to continue to learn more about it in the future. Ultimately, I hope to return home and go into teaching. I think that geosciences is an underrepresented and overlooked study in Trinidad and hope to someday change that view.



Master's Degree Student: Phil Kong

As an undergraduate student at Washington and Lee University, I initially pursued studies in biochemistry. I was fascinated by how many tangible processes in the physical world can be answered through chemistry. During my second year, I found geology when I took an intro to geology course. I quickly became attracted to geology; to be honest, geology gave me a great reason to be outside. I then became fascinated by geochemical processes, where I was able to integrate my knowledge in both chemistry and geology to learn about the physical world around me. My first research project gave me an opportunity to measure hafnium and lead isotopes from mafic lava flows to understand the volcanic history of the Three Sisters mountains nestled in the Cascade Range. Upon graduation, I wanted to continue my research endeavors

in an academic setting by attending Penn State to pursue a master's degree in geosciences.

I became interested in chromium as an environmental contaminant in a physical chemistry course that I took during my senior year of undergraduate studies. Chromium is an intriguing heavy metal. While the reduced form of chromium acts as a nutrient and has a variety of industrial uses, its oxidized form, hexavalent chromium, is a carcinogen. Hexavalent chromium compounds have been shown to cause lung cancer in humans when inhaled. Furthermore, only manganese oxides can stimulate the oxidation of chromium. To investigate this phenomenon, Dr. Peter Heaney and I seek to better understand the chemical mechanism that governs the oxidation of chromium induced by birnessite, a robust and common variety of manganese oxides.

Students in the Spotlight

Phil Kong (continued)

I had the fortunate opportunity to conduct my research using a synchrotron x-ray source at the Advanced Photon Source (APS), Argonne National Laboratory. There, I conducted synchrotron based x-ray diffraction and x-ray absorption spectroscopy to monitor the structure of birnessite as it reacted with aqueous chromium in real time. In addition, I monitored the oxidation state of chromium in the reacted solution to complement the x-ray data characterized birnessite sample during reaction. Beyond my research project, visiting APS has been an enriching experience for me as I got an insight into the lives of beamline scientists that work at the synchrotron. I think they have one of the most remarkable occupations conducting research at a cutting-edge facility on a daily basis.

During my free time, I enjoy running around aimlessly in grassy fields and playing a game that one of my colleagues developed called "Super High Punt." We hope that this game will one day become an Olympic sport. Upon graduation, I hope to use my knowledge in geochemistry to pursue a career in the sciences. I am truly grateful for the experiences that Penn State's Department of Geosciences has provided me and with the opportunities that lie ahead!



Doctoral Degree Student: Virginia Marcon

I am a geochemist who evaluates biogeochemical and physical processes that occur in the shallow subsurface. I am interested in how aqueous fluids interact and influence these environments over time, and how we as humans impact these processes.

I became a geologist through years of curiosity and the encouragement of a family of scientists to ask questions about the world around me. I grew up in Houston, the land of the hot and flat, but fell in love with the western U.S. on our science-centric family vacations. After finding my first geode on a family trip to New Mexico at the age of 3, I was hooked. When it came time to decide where to go to university, the choice was simple, I needed to be out west. I attended the University of Wyoming where I obtained a dual degree in geology and geophysics as well as environmental

natural resources. Wyoming deepened my appreciation for the outdoors and expanded my curiosity in the Earth sciences. At Wyoming, I became immersed in a variety projects that focused on the geochemistry of fluid-rock interactions in the shallow to middle crust. I continued on at Wyoming to complete my M.S. where I studied the evolution of trace metals within a geologic carbon sequestration reservoir and the potential impacts geologic sequestration could have on drinking water resources.

Currently, I am wrapping up my second year of my Ph.D. at Penn State where I work with Dr. Susan Brantley on the effects of lithology on weathering rocks. Specifically, I am interested in how porosity and permeability develop during weathering of different lithologies, and using the rock record to help determine the fundamental processes that control weathering. We use a variety of techniques, including small-angle neutron scattering experiments, to characterize variations in nano-porosity and micro-structures at the bedrock-regolith interface. Understanding these fundamental mechanisms is important for the progress of basic science, development of Earth models, and the ability to evaluate risks in anthropogenically altered systems.

Outside of research, I am an avid yoga and outdoor junkie. I am active in Penn State's Association of Women Geoscientists chapter as well as a co-founder of a new coalition on campus, WE ARE for Science. Our coalition stands up for science at a time in our lives when science is not necessarily respected or trusted. We hope to tackle some of the key issues that we as scientists will face over the next many years including keeping science diverse and inclusive, keeping science in policy, and getting scientists back out into their communities to communicate their science in an approachable way.

My desire to preserve and understand the mountains and streams that I love so much has led me down a path of outreach and conservation. Still unsure of my next steps, I know that I want to continue to interact with communities in order to stir their excitement in the sciences, to start asking questions, and to begin to understand how we as humans rely on the fundamental balance of Earth's systems.

Alumni Spotlight: Christine Regalla



Christine Regalla completed her Ph.D. in 2013 investigating the tectonic evolution of northern Japan under the supervision of Donald Fisher and Eric Kirby. As part of this research, she compiled the history of deformation across the upper plate of the boundary where the Pacific plate subducts under the margin of Asia. She also focused on three active, regional faults in northern Japan and was able to establish the fault geometries, the time since the faults initiated, the rates of fault slip, and in the case of one of the faults, the impact of active fault motion on the evolution of the landscape. In recognition of her research, she was awarded the Doris M. Curtis Outstanding Woman in Science Award from the Geological Society of America (GSA).

During the course of her field work, her study area in northern Japan was hit by a devastating earthquake and tsunami in 2011 that killed more than 20,000 people and caused a meltdown at the Fukushima Daiichi Nuclear Power Plant.

Regalla was part of a rapid response by the International Ocean Drilling Program and participated in the JFAST expedition to drill the plate boundary. Objectives of the expedition were

to measure the thermal signature of coseismic frictional heating across the megathrust; calculate the co-seismic friction coefficient; recover core from the plate boundary decollement, overriding frontal prism and underthrust sediments in a region that experienced ~50m of coseismic slip; and measure in situ stress state from borehole breakouts.

Regalla was a shipboard structural geologist, and her role was to log deformation features in cores recovered from a transect across the plate boundary megathrust. She also used cosmogenic dating to evaluate the age of the accretionary prism. After she left Penn State in the summer of 2013, she took a one-year teaching job at Hobart and William Smith Colleges in Geneva, New York, where she taught the courses Introduction to Geosciences, Structural Geology, and Mineralogy. In 2014 she was awarded an NSF Post Doctoral Fellowship to study the impact of subducting seamounts on the structure and behavior of plate boundaries under the mentorship of C. Rowe and Y. Lui at McGill University in Montreal, Canada. In 2015 she began her current position as a tenure-track assistant professor of tectonics in the Department of Earth and Environment at Boston University, where she supervises undergraduates and graduates conducting field work in eastern California, Vancouver Island, northern Japan, and Cascadia.

An important component of Regalla's research program is related to a multi-institute, international collaborative project to quantify the accommodation of strain in the upper plate of the Cascadia subduction zone in southwest British Columbia. These faults pose a currently uncharacterized potential source of shallow seismicity, and quantification of the timing, magnitude, and kinematics of paleo-ruptures is necessary for informing local building practices. This project involves the combination of structural analyses, mapping of fault scarps and offset surficial deposits, paleoseismic trenching, and quantification of landscape response to active faulting. She has also developed new courses at Boston University including the undergraduate courses Structural Geology and Introduction to Earth and Climate Systems Science, and the graduate course Landscape Evolution.

Regalla is active in her service to the scientific community. She participated in the 2016 CIDER summer workshop on subduction dynamics — a collaborative workshop to help graduate students and postdocs develop interdisciplinary research projects. She was speaker at the Women in Geology Career Pathways Reception at the GSA fall meeting in 2016 and, most recently, she convened a session on subduction zones at the national GSA meeting in Seattle, Washington.

Alumni Spotlight: Enrique Perez



Enrique Perez is walking proof of the transformative power of education. Starting off life in a low-income community, Perez, now with three degrees to his name, plays an important role in the operations of ExxonMobil, the world's largest publicly traded international oil and natural gas company.

Perez credits his success to key people in his life, starting with his parents. Though they did not graduate from high school or college, Perez's parents always stressed the value of education.

"Even before I started formal education, my dad was teaching me math, so once I actually started school, I was way ahead of everybody else," said Perez. "Even though they didn't know firsthand what it was like to go through the educational system, they knew the value of education and they knew this was my way to have a better life."

A native of Washington, Georgia, Perez attended Fort Valley State University (FVSU). Through the multi-university Cooperative Developmental Energy Program (CDEP), Perez received a B.S. in mathematics at FVSU and a B.S. in geosciences from Penn State in five years.

"Geosciences made sense to me and I could visualize the problems we were trying to solve," he said. "Having the math background and applying that to geosciences came naturally to me, and I enjoyed it."

In his classes, Perez ventured out on field excursions to study various aspects of the Earth's development and history. He traveled across the country with the annual Field Camp geosciences course. He obtained an M.S. in geosciences from Penn State, studying with faculty adviser Demian Saffer, professor of geosciences. Graduate research provided Perez the chance to gain a wealth of laboratory experience while investigating strain occurring near tectonic plate boundaries.

"That education allowed me to get to where I am today," said Perez, who, as a geoscientist today with ExxonMobil, helps identify and assess the viability of drilling operations.

Perez said that throughout his academic journey, he received support and guidance from many mentors. Seeing the value in mentoring, Perez has dedicated much of his time to giving back to many communities.

"ExxonMobil really encourages us to be proactive and be part of the community, and they provide a lot of opportunities. We have opportunities to help rebuild homes, help at high schools, and participate in other initiatives," he said.

Perez stays connected with the Penn State community through serving on the executive board of the Graduates of Earth and Mineral Sciences (GEMS) alumni society. He has returned to campus to discuss his experiences with prospective students at the college's signature open house, Earth and Mineral Sciences Exposition (EMEX). He also serves as a mentor in the newly launched GEMS student-alumni mentoring program.

"The GEMS board provided me a way to give back to the college that set me up for success in my life,"

In November 2017, Perez took his giving to a new level by utilizing ExxonMobil's 3-to-1 donation match program for employees. Through this, Perez donated \$5,000 to EMS for the Millennium Scholars program, which provides rigorous academic and financial support to undergraduate students who plan to pursue a Ph.D. and have committed to increasing diversity throughout their careers.

"Having that financial support goes a long way when you're just trying to make ends meet. I'm glad I have the opportunity to help," he said.

Generosity, ingenuity characterized

Geoscientist Michael Arthur met more than one future protégé playing music on the back porch of a friend's house. Casual nighttime jam sessions — gatherings of musically inclined geoscientists — evolved into productive research partnerships. Those relationships were unconventional and highly collaborative, which also describe the more than four decades of work Arthur conducted during his career. He retired on June 30, leaving behind a legacy as an innovative researcher, a champion for budding scientists, and a zealous musician.

Carving out new avenues of research

Growing up in southern California, Arthur spent many days exploring the nearby desert and sleeping under the stars. As a student at San Bernardino Valley College, he thought he wanted to study meteorology or law until he had an “aha” moment in an entry-level geosciences course. Two geosciences professors took students out to the desert to study geology, which opened Arthur's eyes.

“These guys were so enthusiastic, and I realized I could do this as a career,” said Arthur.

He focused his mind on geosciences and obtained both bachelor's and master's degrees in geology from the University of California, Riverside, and a Ph.D. in geological sciences from Princeton University.

At Princeton, he introduced, with his adviser, Alfred G. Fischer, a new way of researching the Earth's past. Arthur and Fischer demonstrated, among other things, how different ratios of carbon isotopes in stratigraphy could reliably be used to understand aspects of the Earth's climate and environment such as the temperature and what organic life existed at the time.

“Later through Al Fischer, I met Peter Scholle, also one of his former students. While at the U.S. Geological Survey together, he and I basically developed carbon isotope stratigraphy, which has become a mainstay for geochemists reconstructing Earth history today,” Arthur said.

He expanded this research to other areas to investigate times ranging from 250 million years ago to 5 million years ago, as well as reaching back to the Precambrian in collaboration with others. Along the way, his research took him to Egypt, Israel, Morocco, Tunisia, Italy, Greece, France, England, Spain, Mexico, Haiti, Japan, Australia, China, New Guinea, and also underwater in the Pacific and Atlantic sea floor. He participated in a number of ocean drilling expeditions and was co-chief scientist of an expedition to the sub-Arctic region. He became an expert in the area of black shales and also co-led oceanographic expeditions to the Black Sea, a



Michael Arthur standing at an outcrop showing the Cretaceous/Tertiary boundary near Gubbio, Italy where he got his start with geosciences research in the 1970s.

modern anoxic basin, and the Peru margin, a region of high biologic productivity and low dissolved oxygen that enhances organic carbon preservation.

“Mike has attacked a series of fundamental problems of Earth history using sedimentologic and geochemical tools, many of which he pioneered,” said Brad Sageman who met Arthur while playing guitar, then became a postdoctoral researcher with Arthur for a year at Penn State. Sageman now serves as professor and chair of Northwestern University's Department of Earth and Planetary Sciences. “In many cases, Mike was the first researcher who identified a particular research question and a novel method to address it, and his approaches were later adopted by scores of other investigators. For example, he helped lay the groundwork for our understanding of how carbon and sulfur isotopes, and other geochemical tools, can be used to reconstruct important geological processes during the Earth's past.”

Leading a department

Arthur came to Penn State in 1991 to become geosciences department head. Right away, he looked at ways to increase collaboration among faculty. He and John Dutton, dean of the College of Earth and Mineral Sciences at the time, rearranged office spaces for faculty and students to facilitate partnerships.

“I tried to mix and match so there weren't segregated floors, hoping there would be more interaction and appreciation for

geoscientist's forty-year career

what each faculty member did, regardless of discipline. It's better for the students and the department," he said.

"Many of Mike's initiatives as department head created an esprit de corps that we didn't have before that because we had been acting like research entrepreneurs. We started appreciating how productive and creative our colleagues were," said Rudy Slingerland, professor emeritus of geosciences, who succeeded Arthur as department head.

Arthur's methods of inducing collaboration rubbed off on at least one of his protégés.

"I spent a year as a postdoc at Penn State working with Mike, and I have maintained contact with him and other Penn State colleagues over the years. Thus, I have a fairly good idea of the things Mike did as a department chair to strengthen Penn State's program, and of how critical the excellent faculty collaborations were to their success," said Sageman. "I have worked very hard to build the same kind of model here at Northwestern, and I credit a lot of our success to Mike's mentorship."

Helping protégés launch their careers

Arthur recognized that he had many supporters throughout his career who helped him to grow.

"Every step of the way, there seemed to be someone encouraging me, and I really appreciated being able to have that. I've been extremely fortunate," he said.

In turn, he devoted many hours to making sure that his mentorship could be a springboard for his protégés' careers.

"Mike has authored more than 160 papers, and many of them are key, insightful papers on which he or his students are first author," said Slingerland.

Having his students as co-author or first author was intended to help them catapult their careers. As soon as he and his protégés explored a new area of geosciences, he would let them continue developing that line of research.

"Mike had capacity to do pioneering work in a whole new field and pass off to his mentees and help launch their careers, which is a huge act of scientific generosity and a lesson I learned as well," said Sageman.

Arthur took a somewhat hands-off approach to mentoring his students, while always being available to answer questions, which provided them with experience needed to develop their scientific prowess.

"If it takes longer because they are floundering a bit, it's a good experience," Arthur said. "Making mistakes and maybe

following some dead ends is useful for a scientist. It gives you resilience because things don't always work out as planned. And my students responded in a way that I'm now proud of what they've accomplished."

Applying shale expertise to Marcellus

When natural gas companies began drilling in the Marcellus Shale, Arthur saw an opportunity to share his expertise through outreach to the community. He put together a series of talks as part of the Earth and Environmental Systems Institute's (EESI) EarthTalks lecture series, encouraged by Susan Brantley, director of EESI, to get his message out to fellow scientists and the public.

That project grew with interest around the university, and an interdisciplinary team, which included Arthur, decided a center would help provide education and outreach around Marcellus Shale. The result was the establishment of the Marcellus Center for Outreach and Research. Arthur served as the first co-director alongside Thomas Murphy, extension educator with the College of Agricultural Sciences.

Arthur and Murphy gave hundreds of talks around the Commonwealth on safety, economics, and other questions community members voiced.

"Without being advocates one way or the other, our goal was to help people understand the potential impacts to consider as well as ways to remedy, avoid, or modify these impacts," he said.

This work led to another project related to the oil and gas industry, TOPCORP, led by James Ladlee, assistant director of energy, entrepreneurship, economic, and community development programs, Penn State Extension. The multi-university project focused on best practices and continued education for oil and gas inspectors throughout the U.S. The project received positive feedback from many community members and the industry, and is now overseen by the U.S. Groundwater Protection Council and other groups.

Farming and Folk Rock

In retirement, Arthur plans to wrap up some of his research projects while also helping his wife maintain their sheep farm in Penns Valley, Pennsylvania. He also plans to continue improving his guitar and mandolin skills, playing a range of styles that include folk rock and bluegrass.

"I still have lots of research to publish and work on, so I'll keep doing that. But mostly I'm looking forward to playing more music and helping out with the farm, as well as volunteering with some environmental organizations," he said.

by Liam Jackson

Engelder's expertise helped fuel



Terry Engelder, a world-renowned geoscientist who first predicted there were vast amounts of accessible natural gas within the Marcellus Shale, holds a piece of the Marcellus Shale rock.

Fifty-eight years ago, Terry Engelder wasn't yet a world-renowned geoscientist. He was a kid with a keen interest in science, a passion ignited by the space race and fueled by the funds that flowed into schools as the nation sought the next generation of discovery.

Using a posterboard and markers, Engelder sketched "Faulting in Western New York" for the junior high science fair. Among the layers Engelder shaped below his hometown was the Marcellus Shale, which decades later Engelder would make famous after successfully projecting it as the second-largest extractable natural gas field in the world.

But even a grown-up Engelder, now an emeritus professor of geosciences, couldn't predict how that one estimate would dominate and redefine his decades-long career, which drew to a close in June.

The magic number

During a webinar in 2007, Engelder was asked how much accessible natural gas rested in the Marcellus Shale. He was stumped, so after the event he did what any scientist would

do; he grabbed the first piece of scrap paper he could find and did a quick calculation. The result? That fifty trillion cubic feet of gas — more than twenty-five times the U.S. Geological Survey estimate — could be extracted from the enormous expanse of rock that spans six states.

That piqued the interests of natural gas companies, and, when more data from testing wells started funneling in, Engelder improved his estimate for technically recoverable gas to 489 trillion cubic feet, about eighteen years' worth of total U.S. gas consumption.

"The calculation that I did was based on very little data and a whole heck of a lot of insight. And maybe you could argue that bubble gum and some rubber bands held it together but it worked," said Engelder. "That was the firm number that allowed a lot of people who spent money on this to move forward. That particular calculation was by far the highlight of my career."

Engelder said people recognized that vast reserves of gas were in the Marcellus Shale, but most thought they were inaccessible. But when fundamental changes in technology, through hydrofracturing, or fracking, showed promise in areas such as Texas, Engelder applied that technology to his calculation.

The result led to a natural gas boom that — for the first time in decades — allowed the nation to extract more natural gas than it used. It also led to a boom in jobs for the region and hundreds of millions of dollars in lease bonuses flowed into the region.

"In terms of satisfaction, very few scientists can say that they did something that affected a lot of people in the state and the nation in such a palpable way," said Engelder. "The amount of money that was spent in Pennsylvania, particularly off of the excitement generated by that initial projection, was rather remarkable."

That projection thrust Engelder into the spotlight, as well. He's been interviewed by nearly 600 reporters worldwide. He's been cited by *Foreign Policy* magazine's "Top 100 Global Thinkers," alongside former President Barack Obama, Bill Gates, and Mark Zuckerberg. He's served on commissions advocating for the safe extraction of natural gas for Pennsylvania governors Tom Corbett and Tom Wolf.

Engelder said despite losing valuable research time during those years of intense public interest in his expertise, he doesn't regret the countless hours he's spent educating the public and advocating for U.S. energy sustainability.

natural gas boom across nation

“There are a number of ways that science manifests itself,” said Engelder. “One way is writing peer-reviewed papers. Another is serving as a liaison between science and the public, and very few scientists have the opportunity for such intense interaction with the public.”

He does have one regret.

Mid-boom, he was two hours into an interview when *Time* magazine’s Bryan Walsh asked if he could take a picture of a piece of Engelder’s Marcellus Shale. Rushed for class, Engelder shooed the reporter away.

A few months later, after touching down in Houston, something in the newsstand caught his eye. “I saw someone else’s shale on the cover of *Time* magazine and realized that I just really blew it because I had a chance to have a piece of my shale grace the cover of *Time* magazine,” said Engelder.

Jack of all trades, master of none

Engelder said his eclectic mix of expertise has been both a blessing and a curse. He said scientists with a more narrow focus tend to garner more accolades. Yet he’s been all over the geological map.

After earning a master’s degree at Yale, he studied fault gouge, rocks formed by tectonic forces, and earthquake generation while earning his doctorate at Texas A&M University. For his postdoctoral work at Columbia University, he branched out into other areas of geophysics including the measurement of stress in the Earth. By the time he became a member of the Penn State faculty, returning to where he received his undergraduate degree (‘68) while running track and cross country, his research had shifted to understanding rocks of the Appalachian Basin that are involved in the accumulation of oil and gas deposits.

That pogo-stick approach to research, he said, led to collaboration with scientists featured in three unique projects that were cover stories in *Time* magazine.

He researched friction with Chris Scholz, who was quoted in a 1975 cover story “Earthquake Prediction.” His time in the field with Walter Alvarez, who discovered that a massive meteor was behind the demise of dinosaurs, led to “Dinosaur Extinction” in 1985. And his Marcellus Shale prediction led to the 2011 cover story “This Rock Could Power the World.”

Keeping busy

Retirement will afford Engelder time to dive deeper into some of his hobbies. He’s working on a book on the fracking industry and the pushback surrounding the boom. He’ll also

invest more time on an art interest that surprisingly ties back to his expertise: craquelure, or the study of how painted works, including famous masterpieces in museums from the Louvre to the National Gallery, crack due to time, materials, and paint.

Engelder has become somewhat of an expert on craquelure, giving talks on the topic at the Palmer Museum of Art at Penn State. It all started during a trip to the Louvre in France.

“You can look at an outcrop of the Marcellus Shale that has some fractures in it and the geometry of those fractures are nearly identical to the fractures in the Mona Lisa’s face,” said Engelder. “The cracks just jumped right out at me. I immediately recognized that these were patterns I was familiar with from studying rocks, so off I went.”

Engelder said craquelure can be used to identify counterfeit paintings because it’s impossible to recreate the exact patterns of the world’s masterpieces. It’s also an important tool, he said, in understanding the materials used at the time and the artist’s method of paint application.

He’ll also have more time to spend with his wife, Janice, whom he met on a blind date in 1968. She was a math education major at Penn State (‘69). After the family, including children, Zoe, Stacey, and Todd, returned to Happy Valley in 1985, she taught math classes at Bald Eagle Area High School, including statistics, calculus, geometry, and a couple levels of algebra.

‘The thing I’ll miss the most’

Engelder said he’s been honored to mentor and nurture so many young people in their quest to become experts in the field.

“The thing I’ll miss the most is the excitement that I find in dealing with young people,” said Engelder. “I still get excited when walking into a classroom. I still get a kick out of seeing all these eager faces. Some are there just ready to listen and soak it in. Others are there challenging me to pique their interest in the subject. I think that anyone who has taught for any length of time will tell you that sense of the classroom is something you will always miss.”

He’s also going to miss his colleagues.

“We have one of the finest geosciences departments in the world,” said Engelder. “They’re an amazing group of people to work with and to be around. I’m going to miss being a part of this group of people.”

By David Kubarek

49th Annual Graduate



*Above: Needles district of Canyonlands National Park in Utah
Photo by Sheila Trampus*



*Left: Night glow from Halema'uma'u lava lake,
Kilauea volcano, Hawai'i
Photo by Kirsten Stephens*

*Right: The Vermillion Cliffs facing the Pink Cliffs of Aquarius Plateau,
North Rim of the Grand Canyon
Photo by Claire Cleveland*



Colloquium Photo Contest



*Above: Jackson Lake near Colter Bay overlooking the Teton range
Photo by Peter Miller*



*Above: Robert H. Treman State Park, Ithaca, New York
Photo by Zachary Richard*



*Above: Fire in the San Gabriel Mountains east of Los Angeles
Photo by Alexander Neely*



*Above: Convict Lake in Mono County, California
Photo by Joanmarie Del Vecchio*



*Left: Graduate Students on canoeing trip in 2015
Photo by Alexander Neely*



Geosciences students from left to right at the WE ARE for Science November, 2016 “Call for Action” Meeting: Allison Karp, Helen Gall, Virginia Marcon, Abby Kenigsberg, Cecilia Cullen, Mercedes Gainor, Judi Sclafani, Joanmarie Del Vecchio, Allison Fox, Shelby Lyons, Victoria Fortiz.

The power of collaboration: The Association of Women Geoscientists and WE ARE for Science come together in a time of change

On November 9, 2016, the Association of Women Geoscientists (AWG) hosted a breakfast with Jackie Huntoon, a visiting scholar and alumna '90g. These breakfasts are an AWG tradition and allow students to have an informal discussion with visiting female professional geoscientists. The discussions normally focus on career trajectories, professional experiences, and advice on being a woman in science. However, the general tone of this breakfast was unlike any other as it was the morning after the surprising outcome of the U.S. presidential election.

During the breakfast, the group discussed how we might conduct science in this new political climate. Despite the unexpected results of the election, our breakfast conversation remained positive and focused on the actions that early career geoscientists could take to help secure the prosperity of STEM fields. After our stimulating meeting, members of AWG began to brainstorm how to become more politically involved as scientists.

One short week later, AWG hosted the inaugural WE ARE for Science (WAFS) meeting. This meeting brought together students, faculty, staff, and residents from across the Penn

State and State College communities. The gathering became a call for action aimed to consolidate and amplify the ongoing efforts within Centre County that advocate for change, action, and inclusion within science.

The initial meeting drew a crowd of more than one hundred people. Those attendees formed three working groups, with a focus on science communication to the general public; science advocacy and policy; and the promotion of security, safety, and inclusion of a diverse community within the sciences.

By the end of the first brainstorming session, we had inventoried the needs and paths forward for each subgroup and the greater organization, and developed the following mission statement for our new coalition: WAFS aims to promote the accurate representation of science in policy, education, and society, while promoting the success of a diverse generation of scientists.

Since November, AWG and WAFS have focused their efforts on undergraduate mentorship through graduate mentor-undergraduate mentee partnerships; write-nights, which

aim to strengthen science communication skills; networking events across various disciplines and diverse groups; panel discussions that focused on an array of topics from diversity on campus to climate change advocacy; and the strengthening of ties between Penn State scientists and the State College community.

Outreach events at local schools and communities are one of the main collaborations between AWG and the WAFS communication subgroup. The two organizations have worked closely with Discovery Space and the American Association of University Women (AAUW) to promote an appreciation of science among children and encourage STEM careers, specifically among young girls.

The WAFS Science Policy subgroup has worked closely with the Penn State Science Policy Society to encourage communication between Penn Staters and their local and state representatives. Major events included a phone banking session where students and faculty were emboldened to call their representatives. They have also been working on developing a collaboration between STEM departments across the BIG Ten.

The WAFS diversity subgroup has worked closely with the EMS Educational Equity Office and multiple STEM departments across campus. Together, these groups host monthly mixers that create a space for students and faculty members from underrepresented groups to meet and develop ties within the Penn State community. The subgroup also plans to shed light on diversity among scientists through a social media campaign called the “Faces of Science.”

The WAFS organization has been actively involved in international efforts to bring awareness to science. In April, WAFS teamed up with various student organizations and institutes across campus to transport 150 Penn State and State College community members to Washington, DC to attend the March for Science.

Just one week later, WAFS participated in the Centre County sister event, the People’s Climate March. At this event, WAFS hosted an “Ask A Scientist” booth in which over fifty Penn State students and faculty from more than twenty disciplines brought their research to the general public and opened the floor for discussion. The goal was to stimulate conversation, and to make science less opaque and scientists more approachable.

Future goals of AWG and WAFS include the continuation of these successful events with an emphasis on improving the public’s image of science. We hope these organizations will continue to grow and work together on tackling the issues that face science and scientists in a continuously changing political and academic climate.

by Helen Gall, Abby Kenigsberg, Virginia Marcon, and Judi Sclafani

Did You Know...

Department of Geosciences Alumni Advisory Board

Did you know that the Department of Geosciences works with a group of alumni who provide guidance to the department and the department head? The principal role of the Alumni Advisory Board is to offer advice, guidance, support, and assistance with emphasis on the educational and research goals of the department, and in establishing and fostering professional linkages. The board is composed of volunteers from government, industry, consulting, and academic professions and includes those with Penn State undergraduate and/or graduate degrees in geosciences. The alums return twice each year to the University Park campus for board meetings.

The board activities include:

- Assisting the department to develop its vision and goals, and assisting the department to achieve those goals
- Building links between the department and its stakeholders (industry, the profession, other academic departments, government, professional bodies, staff, and students)
- Providing advice on the development of the curriculum
- Assisting in the identification of advisors and mentors from industry, government, and professional societies
- Providing a professional perspective on current and foreseeable future needs in research and education
- Providing advice on career development for department students and alumni
- Assisting in fostering philanthropy for the benefit of the department and college
- Being ambassadors for the department to other alumni and organizations
- Other matters upon which from time to time the department head may seek assistance or advice

2017 Board Members

Rick Abegg '83	Kent Newsham '78
Randall Cygan '80g '83g	Dave Russ '86
Larry Garmezy '81g '83g	Roland Sauermann '91
Erica Howat '02	Daniel Stephens '71
Jackie Huntoon '90g	Rick Wardrop '88g
Christina Lopano '07g	

This and That

Karen Wenrich and Lenny Wildrick get married

It took fifty years from the time Karen Wenrich '69 '71g '75g and Linton (Lenny) Wildrick '69 '76g met in Robert Schmalz's GEOSC 001 class for Lenny to ask Karen to marry him. They reunited recently and were married March 7, 2015 in Tucson, Arizona. They sat next to each other in geology classes, due to the old tradition of alphabetical seating (note the similar last names), and had occasionally been in touch over the years, mostly at geological conferences. Lenny lost his wife in 2012. In late 2013, Karen invited Lenny to join her for two weeks on her houseboat on Lake Powell, Utah. Mutual admiration grew into love and Lenny proposed to Karen in October 2013 on the Olympia, Washington waterfront, located near his Tumwater home of thirty years. The wedding was attended by one hundred people, more than fifty of them being geoscientists, and held at Karen's ranch in Tucson. Attendees included Penn State classmates Ihor Kunasz, John Grimes, Boies Hall, Dick Turpin, John Pappas, and Mary and Alan Darnell. At the wedding, Bruce Geller, curator of the Colorado School of Mines Geology Museum, serenaded them with his mandolin playing (see photo) and Ihor and Zenia Kunasz sang them a Ukrainian wedding song with their beautiful opera voices.

Karen spent twenty-three years with the US Geological Survey in Denver, Colorado. After that she spent three years with the International Atomic Energy Agency (IAEA) in Vienna, Austria as a senior uranium geologist, where she shared in IAEA's receipt of the 2005 Nobel Peace Prize "For their efforts to prevent nuclear energy from being used for military purposes and to ensure that nuclear energy for peaceful purposes is used in the safest possible way." Lenny spent twenty-two years with Washington's Department of Ecology and is currently with the Pacific Groundwater Group in Seattle, Washington. Karen

currently consults as an independent economic geologist and Lenny consults as a hydrogeologist. Lenny and Karen can frequently be found giving or listening to talks at geological conferences. They also can be found at their gem and mineral booth at the Geological Society of America National meetings, or at other gem and mineral shows in Denver and Tucson.

Karen and Lenny split their time among homes in Tucson, Golden, Colorado, Karen's home of forty-three years, and Tumwater. They are members of Penn State Alumni Association's Tucson, Arizona and Denver, Colorado chapters. Lenny managed about forty touchdown pushups during this year's high scoring Rose Bowl viewing with Tucson members. They keep in touch with many Penn State friends, including emeritus professors Duff Gold, Roger Cuffey, and Will White. They welcome contact from other classmates, particularly those that they have lost touch with. Lenny can be contacted at Linton@pgwg.com or 360-561-5691 and Karen at CrystalsUL@aol.com or 303-908-4983.



Update from Donald Siegel

I left Penn State in 1971, after completing my master's degree, under the mentorship of Gene Williams and Lauren Wright, to spend two years in the oil patch for Amerada Hess. I then earned my doctorate in hydrogeology from the University of Minnesota. Following that, I worked for eight years with the USGS, conducting research in deep basin hydraulics, shallow oil contamination, and lake and wetland hydrology, along the way gaining skill sets that combined aqueous and isotopic geochemistry and numerical methods in hydrogeology.

I left the USGS to forge a 35-year academic career at Syracuse University, from which I be retiring in December 2017.

At Syracuse, I engaged in new research thrusts (e.g. water resources, climate change, wetlands, and fracking), worked in international settings (China, Europe, and Africa), and

mentored about 70 graduate students to successful careers. I've taught about 10,000 students in my classes and published about 4,000 pages of scientific prose, of which maybe one in ten may have long-standing merit.

In anticipation of retirement, I recently joined a consulting firm that provides expertise on various water environmental issues. I also will be starting a modest career playing solo, fingerstyle jazz on guitar at coffeehouses, receptions, and wineries.

My wife Bette still edits newspapers and caters large dinners. My kids, Micah, Esther, and Hannah —now adults — are doing fine in their own careers. My first grandson, Caleb — Micah's son — has now begun to walk and talk.

Donald Siegel, Laura J. and L. Douglas Meredith Professor, Department Earth Sciences, Syracuse University

Reminiscing about emeritus faculty

This reminiscence was sent in by Kent Newsham '78, chief of petrophysics at Occidental Petroleum Corporation

Eugene Williams

Gene served as my informal adviser for my senior thesis, “On the Origin of the Carolina Bays.” His guidance began with his mentorship in the spring of 1977 when he was a live-in professor during the Wallops Island Marine Science adventure. Gene transcended his role as “just a leading professor” by providing life lessons through his nearly daily philosophical lectures and discussions that would last into the wee hours of the evening. We all recognized that Gene was thinking faster than he could speak, exemplified by frequent “Billy Pilgrim” type pregnant pauses in dialogue where he would just stop speaking, staring into space — truly lost in space and time moments. But then, he would return and pick up the dialogue without any gap in continuity. Gene’s insights, ability to motivate, and patience were all impactful for me as I transformed the Wallops Island fieldwork on the Carolina Bays into a 200-page thesis. I believe Gene may have been one of the few that actually took the time to read the entire document! Gene’s close relationship with Robert Scholten resulted in my redirection, post Wallops, into the energy industry. It was Gene who highly recommended that I take Robert’s Petroleum Geology course.

Robert Scholten

Although I knew Robert less well than Eugene, his impact on my career direction was emphatic. After taking Gene’s advice and enrolling in Robert’s Petroleum Geology class, he had me captivated on the first day. Robert’s instruction was so practical and fun that I knew this was the right direction for me. Wallops taught me that I did not get along well with boats — a poor match for a marine geologist. I was aware of some of Robert’s exploits during WWII and heard some of his stories as a Nazi prisoner. His courage at such a young age told me much about the man. It was Robert who provided the vision for my future career track. He was aware of my “contract with my Dad,” which required graduation and a job upon completion of my undergraduate degree or full reimbursement plus 10 percent yearly interest. After taking Robert’s Petroleum Geology class, I wanted to work for an oil company. However, I would need a master’s degree. Robert provided an alternative solution. He said, “Go work as a wireline logging engineer, for a company such as Schlumberger for a few years, learn log analysis, and

then you’ll be able to apply to an oil company based on your experience.” Robert’s recommendation became reality.

Roger Cuffey, Albert Guber, and Duff Gold

Since I’m on the subject of impacts, I would be remiss not to mention Roger Cuffey, Albert Guber, and Duff Gold’s influences. Roger was my undergraduate adviser and managed to keep me out of trouble with the administration numerous times. This was especially true in my senior year when I refused to take Dean Hosler’s class, Writing the Undergraduate Thesis. I was actually the spokesperson for the group of Wallops Island students, all who felt we were way ahead of the game due to our prior Wallops activity and experiences. Most of us were using our Wallops projects as our undergraduate theses. We felt Dean Hosler’s class was going to be a “waste of our time,” or at least that’s what I told him. That conversation was rather brief and terse. Thinking it best to ‘warn’ Roger about the dean’s less than accepting perspective, I walked through the fossil catacombs that was Roger’s office, only to see him holding the phone a good distance from his ear guarding against the dean’s agitated voice. Roger mouthed to me, “what the #@## did you say to him?” Roger had my back and was able to convince Dean Hosler that the Wallops “kids” could manage the thesis without attending his class and still get the credit!

I view Al Guber as one of the truest educators at Penn State. As the director of the Wallops Island project, he impacted scores of students with the program. He gave unselfishly to the program at the personal cost of reducing opportunities to perform research and publish. I view Al as the most honorable of professors, by the noble practice of educating, which still remains the most important charter of the University.

Duff Gold’s influencing style was similar to Gene’s through both teaching and good personal advice. To this day, I still use the basics taught by Duff in his Structural Geology class, especially in the analysis of dipmeters. But the most important influence was in his practical advice about life and business. As a senior, I was very concerned that I didn’t have all the tools needed to be successful in business. During a field trip to a manufacturing company, Duff pulled me aside, after having overheard some of my concerns, to provide some insight. He simply suggested that university learning was just the start and that life is about continuous education, every day. He said, “It’s a good day when you learn something, so make every day a good day.” I try to live by this motto daily.

Alumni Passings

Dr. Richard E. Bergenback '64

Mr. Paul H. Farrell '87

Mr. Ronald L. Kerl '65

Mr. Marion W. Titus '49

Mr. Charles A. Brinkley '64

Mr. William S. Hoffman '77

Mr. George R. Macaulay '52

Dr. Charles L. Trotter '63

Mr. John C. Buffington '69

Dr. Arthur M. Hussey II '54

Dr. Mark Pagani '98

Mr. William B. Wigginton '58

Dr. John H. Carman '69

Mr. David E. Johnston '82

Mr. Jeffrey R. Peffer '71

Geosciences Field Camp 2017

The Penn State Geosciences Field School had an extraordinary year, with more than fifty students participating — all from Penn State — and a caravan of eleven vehicles. In late May 2017 the class left the Deike Building parking lot on the annual trip out west for a six-week investigation of the geology of the intermontane western U.S. This was the largest field camp class since the early 1980s, and exercises were led at different times by six different faculty in the Department of Geosciences.



Five of the six exercises utilize Arc-GIS and GPS, but students still compose geologic maps on a topographic base map and use these results to evaluate geologic features and processes and how they vary in space and time.

For the first exercise, Rudy Slingerland came out of retirement to lead an investigation of the sequence stratigraphic

relationships recorded in the Book Cliffs of Eastern Utah, followed by a move to Yellowstone Bighorn Research Association in Red Lodge, Montana, with Erin DiMaggio introducing the students to geologic mapping in Elk Basin. For the third year in a row, the class moved to the Teton Village in Wyoming where Roman DiBiase directed a study of the Quaternary glacial geology and the active faulting along the mountain front of the Tetons. The class then camped in the Pioneer Mountains in east-central Utah for an exercise led by Donald Fisher to evaluate the history and landscape evolution of an area with a complex history of tectonics and volcanism.

As in past years, the course finished in Alta, Utah where maps and cross sections were used to estimate fault slip and shortening in the overthrust belt. In the last exercise directed by Kevin Furlong and Andrew Smye, the students mapped metamorphic isograds around the Alta Stock as a constraint on models for the thermal evolution around cooling, intrusive igneous rocks. Results from the overthrust and stock exercise were placed in the context of the geologic history of the Wasatch Range of Utah. There were six teaching assistants, supervised by Erica Pitcavage, who were instrumental in managing such a large class: Al Neely, Joanmarie Del Vecchio, Mercedes Gainor, Kenneth Roop-Eckart, and Kirsty MacKenzie.



Above: Kevin Furlong and students at an outcrop within the Alta Stock field area.



Left: Erin DiMaggio instructs students in mapping at Elk Basin.



Left: Roman DiBiase leads the exercise along the mountain front of the Tetons.



Above: On the way down after a long day.

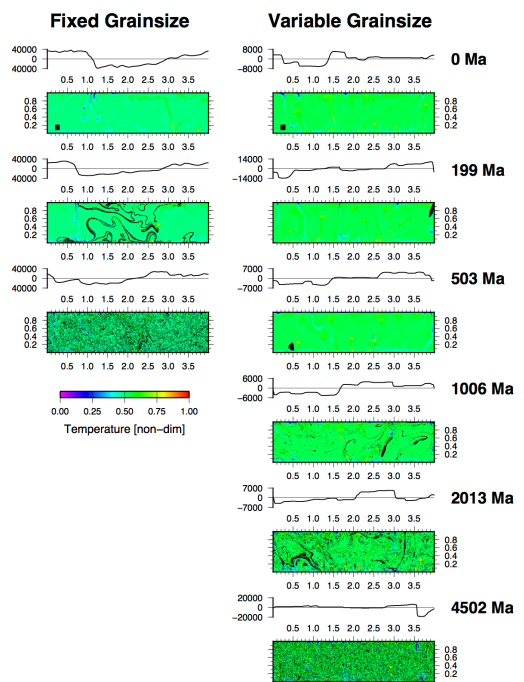
Combining computer modeling and geochemistry to study Earth's ancient past

Plate tectonics is responsible for most of the features of the Earth we are most familiar with, including mountain ranges such as the Appalachians, Rockies, or Himalayas; earthquake faultlines; and volcanoes. That plate tectonics is operating at the present day is well documented by Earth scientists. However, why plate tectonics operates on the Earth and when it might have begun is not well understood. Earth is actually the only rocky planet or moon in our solar system where plate tectonics is known to occur. The other rocky planets, Mercury, Venus, and Mars, show no strong evidence for plate tectonics. Instead, they are thought to have “stagnant lid” tectonics. With plate tectonics, the surface of the Earth is broken into multiple plates, which slide past each other, spread apart from one another, and collide and sink beneath each other at plate boundaries; it is this movement of the plates that causes earthquakes. An important part of plate tectonics is subduction, where one plate sinks beneath another. Subduction happens as plates grow old and cold, and become heavy enough to sink into the mantle beneath them. This sinking is the main driving force that causes plates to move and drives convection in the mantle. With stagnant lid tectonics, the surface acts as one single plate and no subduction takes place. As a result, there is no movement of surface plates with respect to one another. The entire surface is “stagnant” and forms a “lid” on top of the mantle convecting beneath. Understanding why mantle convection on Earth results in plate tectonics, while it does not on Mars or Venus, as well as understanding how and when plate tectonics started on Earth, is one of the main goals of Brad Foley’s research.

Determining when plate tectonics started on Earth is difficult because few rocks from the ancient Earth are preserved today. With a limited rock record, only indirect evidence can be used to determine whether Earth had plate tectonics, stagnant lid tectonics, or some other style of tectonics entirely. Geologists can determine the conditions under which ancient rocks formed, and then try to interpret these conditions as being indicative of a particular style of tectonics. Another difficulty is that it is hard to tell if rocks seen in one location tell us about what the entire Earth was like in the past, or whether they only inform us about tectonics at a specific location. Despite these difficulties, most geologists think that plate tectonics was in operation by three billion years ago. Though what the Earth was like before this time is still heavily debated.

However, regions of the mantle that record chemical variations formed soon after the Earth formed, more than four billion years ago, can potentially be used to study tectonics on the very early Earth. The chemical variations are products of radioactive isotopes that completely decayed away within the first 500 million years of Earth’s formation, and cannot be created after this time. Rocks show evidence of these ancient chemical variations (or mantle “heterogeneity”) lasting up to two billion years ago. This means that the early-formed mantle heterogeneity must have existed for the first one to two billion years of Earth’s history. It is surprising that vestiges of the ancient Earth’s chemical makeup could last for so long, because the vigorously convecting mantle should have mixed early formed heterogeneity with the rest of the mantle, effectively erasing it. Mixing of heterogeneity is thought to be especially fast, three to four billion years ago, because the Earth was initially hotter and has cooled over time. A hotter mantle convects more vigorously and therefore erases heterogeneity more quickly, all else being equal.

Some studies have argued that the survival of ancient mantle heterogeneity is evidence for stagnant lid tectonics on the early Earth, as stagnant lid tectonics leads to slower mixing of the mantle. However, Foley, in collaboration with geochemist Hanika Rizo from Carleton University in Ottawa, Canada, has recently shown that plate tectonics may have operated more slowly in the past, and therefore lead to slow mixing. Foley and Rizo used computer models of mantle convection that include tracking how the size of mineral grains that make up mantle rock change over time. When grains are larger, mantle rock is stiffer and convection is less vigorous. Grains also grow faster at higher temperatures, leading to generally larger grain sizes as mantle temperature increases. Foley and Rizo showed that the effect of grain size, not previously considered in earlier studies, results in slow mixing for the early Earth’s mantle. When the temperature is higher, mineral grains are larger, and as a result heterogeneity can be preserved for long timescales even with plate tectonics. The study was recently published in the journal *Earth and Planetary Science Letters*.



Images of mantle convection with black tracers representing mantle heterogeneity; mixing of tracers throughout the mantle represents the erasure of heterogeneity. Images are recorded for specific times during the model, which are given in the right hand side of the figure in millions of years. When grainsize is allowed to vary (right column) it takes billions of years for heterogeneity to be mixed with the rest of the mantle.”

by Brad Foley, assistant professor of geosciences

Undergraduate Scholarships & Awards

Baker Hughes Scholarship Award: *Natasha Nagle, Sapol Raadnu*

Thomas F. Bates Undergraduate Research Enhancement Fund: *Abdulla Abdulrahman, Megan Haney*

Joseph Berg Award for Undergraduate Research in Geosciences: *Jiawen He, Anna Whitaker*

Barton P. Cahir Award: *Huiwen Chen*

Frank Dachille Memorial Award in Geochemistry: *Anna Ablak*

David M. Demshur Undergraduate Research Endowment: *Doug DiNardo, Audrey Dunham, Brent Michael Fleming, Amara Fofana, Cassie Hanagan, Megan Haney, Mitchell Scott Hastings*

Edwin L. Drake Memorial Scholarship: *Arnold Eatmon, Lisa Marie Glendinning, Nicholas McCarroll, James McDonough, Aileen McNamee, Cole Messa, Robert Miles, Rachel Miller, Noel Montalvo, Matthew Morell, Madeline Nyblade, Nathan Pennypacker, Cheng Tarnq, Jack Phillips, Tongzhang Qu, Emily Ann Reich-Acosta, Nicholas Riqueros, Gina Sarkawi, Patryk Szastak, Cheng Tarnq, Kass Ulmer, Kittichote Veeranuntawet, Tyler White, Stephen Williamson, Ian Wolfe, Mark Yesko*

General Scholarship Endowment in Geosciences: *Nicholas Schuler, Ian Wolfe*

David P. "Duff" Gold Undergraduate Scholarship Fund: *Erin Redwing, Adreina Shamelia Shamsul Anuar*

John C. and Nancy Griffiths Scholarship: *Emily Loucks, Cole Messa*

James and Nancy Hedberg Scholarship: *Priyanka Bose, Collin Charnoff, Kyle Sherbine, Kittichote Veeranuntawet*

Arthur P. Honess Memorial Fund: *Cathleen Baker, Zachary Czuprynski, Wen Jou Lin, Gina Sarkawi*

Benjamin F. Howell, Jr., Award: *Audrey Bourne, Matthew Feliciano*

Kappmeyer-Isaacs Field Camp Award: *Ziyad Almanimoni, Audrey Bourne, Huiwen Chen, Zachary Czuprynski*

Ronald A. Landon Endowment in Hydrogeology: *Safya Alpheus, Catherine Hanagan*

Earle S. Lenker Fund for Field Studies in Geology: *John Dibert, Megan Haney, Dan Heilemann, Taylor Hochbein, Charles Huang, Xialong Jiang*

Reif Undergraduate Summer Field Camp Award: *Austin Johnston, Jessica Krizan, Adam Lewis, Wenzong Lin, Mary Yesko*

Robert F. Schmalz Award: *Huiwen Chen, Beth Ann Eberle, Callan Glover, Jiawen He, Emily Loucks, Rachel Miller, Noel Montalvo Cruzado*

Dr. David E. Vaughan and Mrs. Julianne Vaughan Field Camp Fund: *Priyanka Bose, Nathan Carpenter, Terrance Delisser, John Dibert, Amara Fofana, Aileen McNamee, Cheng Tarnq, Tyler White*

External Scholarships & Awards

Erickson Discovery Grant: *Madeline Nyblade, Gina Sarkawi, Kyle Sherbine, Anna Whitaker*

Geological Society of America Student Research Grant: *Allison Fox*

NASA Earth and Space Science Fellowship: *Greg Wong*

Penn State Graduate Exhibition Awards: *Joanmarie Del Vecchio, Austin White-Gaynor, and Maeva Pourpoint*

Graduate Scholarships & Awards

Alley Family Graduate Scholarship: *Joanmarie Del Vecchio and Shelby Lyons*

Chevron Scholarship: *Peter Miller and Abby Kenigsberg*

Hess Corporation Exploration & Production Technology Scholarship: *Kerry Ryan*

Charles E. Knopf, Sr., Memorial Scholarship: *Chas Bolton, Josh Woda, Gabrielle Ramirez, and Kirsty McKenzie*

Krynine Memorial Award: *Elizabeth Andrews, Chas Bolton, Zena Cardman, Christian Clark, Claire Cleveland, Evan Greenberg, Beth Hoagland, Allison Karp, Phil Kong, Virginia Marcon, Uyen Nguyen, Maeva Pourpoint, Gabrielle Ramirez, Haley Ramirez, Kerry Ryan, David Soto, Srisharan Shreedharan, Kirsten Stephens, Austin White-Gainor, Josh Woda, Greg Wong*

LeBlanc Fellowship: *Austin White-Gaynor*

Marathon Alumni Centennial Award: *Kerry Ryan*

Hiroshi and Koya Ohmoto Graduate Fellowship: *Virginia Marcon and Elizabeth Andrews*

Richard R. Parizek Graduate Fellowship: *Jared Carte and Josh Woda*

Scholten-Williams-Wright Scholarship in Field Geology: *Zena Cardman, Kalle Jabn, and Maeva Pourpoint*

Shell Geoscience Energy Research Facilitation Award: *Chas Bolton, Claire Cleveland, Allison Fox, Evan Greenberg, Abby Kenigsberg, Shelby Lyons, Ben Madara, Peter Miller, Uyen Nguyen, Kerry Ryan, Srisharan Shreedharan*

Richard Standish Good Graduate Scholarship: *Austin White Gaynor and Erica Pitcavage*

Donald B. and Mary E. Tait Scholarship in Microbial Biogeochemistry: *Uyen Nguyen and Allison Karp*

Teaching Assistant Award: *Erica Pitcavage*

Barry Voight Endowment: *Erica Pitcavage*

2017 Graduate Colloquium Awards

Oral Presentation by a Ph.D. Student (Post-Comprehensive Exam)

First: Matt Herman
Second: Kiya Riverman
Third: Kerry Ryan

Oral Presentations by a Ph.D. Student (Pre-Comprehensive Exam)

First: Beth Hoagland
Second: Austin White-Gaynor
Third: Allison Karp

Oral Presentation by an M.S. Student

First: Joanmarie Del Vecchio
Second: Phil Kong
Third: Ashley Grey

Poster Presentation (M.S./Ph.D.)

First: Uyen Nguyen
Second: Helen Gall
Third: Greg Wong

Energy Related (M.S./Ph.D.)

First: Victoria Fortiz
Second (tie): Ben Madera
Second (tie): Josh Woda

These candidates were selected from an impressive group of participants. We would like to offer a special thank you to the Shell Corporation and the Cannon Family Fellowship for their continued support of the Graduate Colloquium.

2017 Trustee Scholarships & Endowments

Alley Family Graduate Scholarship in the Department of Geosciences
Arthur P. Honess Memorial Award
Baker Hughes Natural Gas Research Fund
Barry Voight Volcano Hazards Endowment in the College of Earth and Mineral Sciences
Barton P. Cahir Award Endowment in Earth and Mineral Sciences
Benjamin F. Howell, Jr. Award in Geosciences
Cannon Family Graduate Symposium Award in Geosciences
Charles E. Knopf, Sr. Memorial Scholarship
David M. Demshur Undergraduate Research Endowment in Geosciences
David M. Diodato Geosciences Fund
David P. "Duff" Gold Undergraduate Scholarship Fund in Geosciences
Donald B. and Mary E. Tait Scholarship in Microbial Biogeochemistry
Dr. David E. W. Vaughan and Mrs. Julianne S. Vaughan Field Camp Fund in the Department of Geosciences
Earle S. Lenker Fund for Field Studies in Geology
Frank and Lillie Mae Dachille Memorial Award in Geochemistry
Fund for Excellence in Lithospheric Geodynamics in the College of Earth and Mineral Sciences
General Scholarship Endowment in Geosciences
George L. Ellis Scholarship
Geosciences Enrichment Fund
Geosciences Research Fund in Honor of Hiroshi Ohmoto
Heller Marcellus Shale Research Initiative Endowment
Hiroshi and Koya Ohmoto Graduate Fellowship in Geosciences
James and Nancy Hedberg Scholarship in Geosciences
Janet C. Kappmeyer and Andrew M. Isaacs Experiential Learning Fund in Marine Sciences in the Department of Geosciences
Jesse A. Miller Trustee Matching Scholarship in the College of Earth and Mineral Sciences
John C. and Nancy Griffiths Scholarship in Geosciences
Joseph Berg Award for Undergraduate Research in Geosciences
Kappmeyer-Isaacs Field Camp Award
Kent and Helen Newsham Geosciences Endowment in the College of Earth and Mineral Sciences
Michael G. Loudin Trustee Scholarship in the College of Earth and Mineral Sciences
Open Flow Gas Supply Corporation Endowed Program Fund in Geosciences
Petroleum Geosystems Enrichment Fund
RADS Equipment Fund for Field Studies in Penn State Sedimentary Geology
Reif Undergraduate Summer Field Camp Endowment

Richard B. and Cynthia R. Alley Faculty Enhancement Program Fund
Richard R. Parizek Endowment for Field Study in Geosciences
Richard R. Parizek Graduate Fellowship
Richard Standish Good Graduate Scholarship in the Department of Geosciences
R.J. Cuffey Fund for Paleontology
Robert F. Schmalz Award in the Department of Geosciences
Ronald A. Landon Endowment in Hydrogeology
Rudy L. Slingerland Early Career Professorship in the College of Earth and Mineral Sciences
Scholten-Williams-Wright Scholarship in Field Geology
South Jersey Resources Group Endowed Program Fund in Geosciences
St. Mary Land and Exploration Endowed Program Fund in Geosciences
The Bruce Miller Scholarship in the College of Earth and Mineral Sciences
The Paul D. Krynine Memorial Fund
Thomas F. Bates Undergraduate Research Enrichment Fund
Thomas Kenneth (T.K.) Reeves, Jr. Family Scholarship
Timothy B. and Cindy Lynch Mullen Scholarship in Geosciences
Timothy D. Watson Fund in Geosciences

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Dr. Eugene G. Williams
Drs. Chris L. Wojick and Jacqueline Huntoon
Mr. Shawn M. Woll

Alumni News

Robert Avakian '68

Bob received the Outstanding Faculty Award at Oklahoma State University Institute of Technology where he has been an instructor since 2001.

David Bish '77

David was awarded a Fulbright Fellowship to study in Naples, Italy, for six months. He will be studying the minerology of a variety of artifacts from Pompeii, both fired and unfired.

Joe Campisi '80

Joe recently acquired Corporate Environmental Advisors, an environmental consulting-engineering firm with a thirty-year reputation of helping clients assess and manage environmental risk and achieve regulatory closure on a wide range of commercial and industrial properties in the northeastern U.S.

Keith Carlson '85

Keith was promoted from zone engineer to plant manager at Air Liquide Large Industries, which is also recognized as a technical community leader for air separation technology.

Shawn Goldman '07

Shawn is currently serving as the deputy study scientist for the LUVOIR mission concept study, which is one of four major flagship missions being studied by NASA in advance of the next Astrophysics Decadal Survey.

Steve Holbrook '82

Steve was recently appointed head of the Department of Geosciences at Virginia Tech.

Mahlon 'Jay' Justice '75, '82

Jay recently retired after twenty-two years of teaching physics, geology, and Earth science in the Dallas County Community College District. Prior to his teaching career he spent fifteen years in the oil industry serving as an exploration geophysicist with the Chevron Corporation and as a research scientist with the Atlantic Richfield Company. He now lives in Plano, Texas, where he and his wife, Lori, are enjoying retirement.

Robert Kleinmann '74

Bob retired from the Department of Energy's National Environmental Technology Laboratory five years ago and has been working part time since then as an environmental consultant, first with CH2M Hill and more recently (since September 2016) with HDR. For the past twenty years to now, he has served as the editor-in-chief of the quarterly journal, *Mine Water and the Environment*, which is published by Springer. He remarried eight years ago, thanks to eHarmony, and life is good.

Charles Koval '82

Charles just wrote a career story, "The New Pipeline Rule I Waited Half a Career to See," for his company's website/blog: <https://safetycompass.wordpress.com/2017/04/19/the-new-pipeline-rule-i-waited-half-a-career-to-see>.

Garry Kramchak '73

Garry is fully retired now and enjoying his free time with volunteer work. He is a First Degree Knights of Columbus member and a First Connection volunteer for the Leukemia & Lymphoma Society and CanCare. He also enjoys his hobbies of collections and short road trips to nearby towns, another great way to experience the local history and foods. He says that, "Retirement is very satisfying for me now."

Doug McKee '95

Doug started McKee Environmental, Inc., an environmental consulting business in 2013 (www.mckeeenviro.com). He is a professional geologist and lives in Bellefonte, Pennsylvania.

Shuhei Ono '01

Shuhei, associate professor in low temperature geochemistry at MIT, was selected as the Paul W. Gast Lecturer for the 2017 Goldschmidt Conference.

Kevin R. Sech '82

Kevin is in his nineteenth year of private consulting as a geologist and engineer for HILBEC Engineering & Geosciences, LLC. His daughter Hilary ('13 Criminal Justice) is working in Connecticut for a law firm and his daughter Rebecca ('15, '17 Biobehavioral Health) recently graduated from Arcadia University as a physician assistant.

Trem Smith '80

Trem was recently appointed CEO of Berry Petroleum Company.

Kathryn West '88

Kathy currently works in the environmental remediation field (AECOM) at a nearly one hundred year old chemical manufacturing client site in southern New Jersey as a project manager in support of university researchers and helps facilitate the development of innovative technologies. She was a co-author on the article "Sediment Monitored Natural Recovery Evidenced by Compound Specific Isotope Analysis and High-Resolution Pore Water Sampling" published by *Environmental Science & Technology* (ES&T) <http://pubs.acs.org/doi/abs/10.1021/acs.est.6b02961>.

Vince Yarina '92

Earlier this year, Vince was promoted to principal at his firm, Langan Engineering & Environmental Services, Inc. He also opened and manages the Fort Lauderdale office in 2015.

Faculty Awards and Recognitions



Richard Alley

~ AGU Climate Communications Prize
~ 2017 Wollaston Medal, Geological Society of London



Peter Heaney

~ E. Willard and Ruby S. Miller Faculty Fellow, EMS



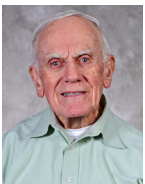
Charles Ammon

~ AGU Fellow



Lee Kump

~ Dean, EMS
~ Robert M. Garrels Award of the Geobiology Society



Hu Barnes

~ Penn State Alumni Association
Honorary Alumnus Award



Chris Marone

~ 2016 Editors' Citation for Excellence in Refereeing for *Geophysical Research Letters*



Timothy Bralower

~ Mitchell Award for Innovative Teaching, College of Earth and Mineral Sciences (EMS)



Andrew Nyblade

~ Penn State's President's Award for Excellence in Academic Integration



Terry Engelder

~ Wilson Award for Excellence in Research, EMS



Byron Parizek

~ Penn State's University College Faculty Scholar Medal



Donald Fisher

~ Wilson Award for Excellence in Teaching, EMS



Barry Voight

~ Elected to the National Academy of Engineering



Katherine Freeman

~ 2017 Alfred Treibs Award, Geochemical Society



Andrew Smye

~ President's Award, Geological Society of London
~ Gladys Snyder Junior Faculty Grant, EMS
~ Rudy L. Slingerland Early Career Professorship



Russ Graham

~ Cozzarelli Prize, National Academy of Sciences



Peter Wilf

~ Fellow of the Paleontological Society



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College of Earth
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