Cornell Engineering

CornellCALS College of Agriculture and Life Sciences

EAS MAGAZINE

Fall 2022

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GEOTHERMAL EXPLORATION AT CORNELL

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MESSAGE FROM THE CHAIR

GEOFFREY ABERS

Fall is in the air in Ithaca—the campus is at its most photogenic, and people are buzzing around the buildings following the quiet summer. After a couple of challenging years, EAS is feeling like it is getting back to normal. People are traveling, going to workshops and giving talks, and resuming field work. We had our first EAS department picnic this September in three years, a great success that was excellently attended, and we are seeing near-normal attendance at seminars. With this return to in-person activities, I am sensing more positivity and enthusiasm in the department and excitement for new things.

This summer's big event was the drilling of the Cornell University Borehole Observatory, or CUBO. As you probably know, CUBO is a scientific observatory that reaches nearly 10,000-feet deep below campus, designed to help assess and manage potential deep geothermal energy projects. As part of minimizing the Ithaca campus carbon footprint, the University is very seriously looking into the prospect of using geothermal energy in the form of deep warm water to heat the campus in the winter—about 40% of the total energy budget. To pull it off, we need to understand the thermal structure, permeability structure and stresses at depth. Hence, CUBO.

Early this summer a large drill rig was raised just past the Cornell orchards, and from mid-June to mid-August full-fledged drilling was underway. If you haven't already, I urge you to sample some of the many weekly two-minute project videos on earthsourceheat.cornell.edu; they are populated with EAS students and faculty, and a few celebrity drop-ins. The operation was the talk of the town all summer, with the drill rig lit up 24/7 and visible around Ithaca. EAS (and other) students and faculty continuously worked the drillhead, pulling cuttings, monitoring progress and farther afield monitoring water quality and seismicity. The drilling ended a couple hundred feet into crystalline basement, followed by a couple weeks of downhole science. The project has been a great way to highlight the importance of what we do in EAS to the broader Cornell community, getting mentions in every college or university gathering all summer—even singled out in President Martha Pollack's welcome to campus message this August. Next up, the CUBO team is working to understand data collected during this marathon drilling session and is working to figure out next steps toward realizing geothermal heat production.

As every autumn, we are delighted to welcome a new crop of graduate and undergraduate students to the EAS family. There have been increases in numbers for both groups; the result of a number of recruitment strategies and, we think, a growing recognition that a modern 21st century Earth and Atmospheric Sciences department provides great educational value. We are seeing stability and increases in undergraduates enrolling in both our majors, showing a way for departments like ours to thrive. We now have one of the largest graduate student bodies in decades, and the most diverse. Similarly, undergraduates are thriving in both majors.

This growth is partly driven by the cohort of new faculty in the department; nine of our current faculty (including six assistant professors) started in the last six years. This cohort is doing excellently, as followers of our quarterly newsletters probably know, and they bring great energy and sense of common purpose. They are also great colleagues to have. They will be joined by three new assistant professors committed to starting in the next two years—Grace Barcheck, Riley Culberg and Jonathan Lin—spanning seismology, glaciology, and extreme weather. We also have an active search in Critical Elements and Minerals Geoscience; stay tuned!

Of course, there are some departures, notably the retirement this summer of Terry Jordan after four decades of leadership in our sedimentology program. Terry was in many ways a trail blazer, one of the first tenured women in the College of Engineering and a top scholar recognized by many awards and accolades. She continues to be a presence in EAS, as one of the faculty leads in the CUBO project, so not really departing!

Recruiting and retaining faculty of the highest caliber propels profound advancements in science with broad-based societal impact. Whether it is a state-of-the-art geochemical analytical facility, HPC computing clusters or field equipment, top-tier faculty require top-tier support from Cornell and from EAS. One Cornell tool for providing such support is the endowed Faculty Fellows program. Endowed Faculty Fellows will allow us to continue to support our superstar faculty and build a long-sustaining program. If this is something that interests you, or you have any other questions about giving opportunities, feel free to contact Alumni Affairs & Development, Paige Onstad at Cornell Engineering (po86@cornell.edu) or Christy Agnese at CALS (cagnese@cornell.edu).

Geoffrey Abers
Chair of Earth and Atmospheric Sciences
William and Katherine Snee Professor in Geological Sciences

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Earth and Atmospheric Sciences

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ON THE COVER
A sunset at the CUBO drill site.

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DEPARTMENTS

SUPPORT EAS

EAS Vision Endowment

Earth and Atmospheric Sciences has been undergoing a period of vigorous faculty renewal which is driving changes in the research thrusts of the department, the graduate and undergraduate curricula offered, and the relationships with other departments in the College of Engineering, CALS, and Arts and Sciences.

The department's presence in three colleges and exciting new initiatives afford tremendous opportunities for **impact across the campus and with the outside world**.

With new opportunities come special needs associated with rapid growth and a university business model that compels departments to function autonomously.

For more information on how your support can make a difference, please email Paige Onstad at po86@cornell.edu.

Support Our Vision

GIVING IMPACT

The Vision Fund enabled purchases of two pieces of geophysical equipment intended for active-learning and experiential-based learning courses, specifically a Noggin ground-penetrating radar system (GPS) with 250 MHz and 500 MHz antennae and a Geonics EM31-MK2 ground conductivity meter. The instruments will be used for field projects and to teach students the logistics of data acquisition, sources of noise, data processing, and data interpretation. The equipment will specifically be useful in applications related to hydrogeophysics, environmental studies, and geotechnical studies. Students will acquire skills useful either for future careers in geoscience industry or for graduate studies. These two new instruments will be used in conjunction with a new geodetic positioning system (GPR) receiver, which will provide precise locations of measurements, and with existing equipment owned by the Earth and Atmospheric Sciences department including a gravimeter and a multi-channel resistivity meter. Initial targets of student investigations will include characterization of buried infrastructure around the Cornell campus and delineation of the buried glacial valleys that host local aquifers.

Understanding the Past. | **Informing the Present.** | **Improving the Future.**

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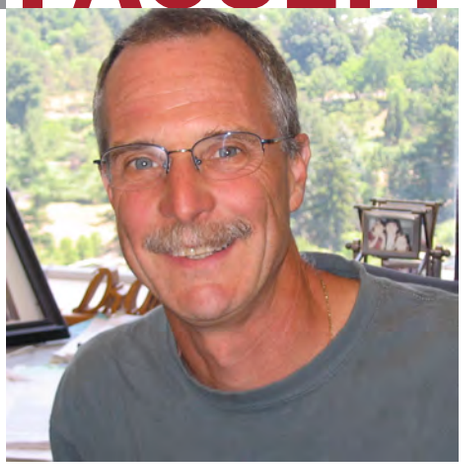
Earth and Atmospheric Sciences

FACULTY NEWS



EAS Professor Art DeGaetano

AMS NAMES ART DeGAETANO FELLOW

Art DeGaetano, professor and Director of Undergraduate Studies for Atmospheric Sciences in the Department of Earth and Atmospheric Sciences, has been named a Fellow by the American Meteorological Society.

"I am honored by this recognition," DeGaetano said. "It is rewarding to know that my colleagues—both here at Cornell and across the country—value my contributions to the field."

"This is a tremendous honor for Art," said EAS Chair Geoffrey Abers. "Fellows are an elite group with no more than 0.2% of members being elected each year."

"I was flabbergasted by all the congratulation and kind words I received from so many former students!" said DeGaetano.

DeGaetano's research focuses on applications of climate data. This work involves the development and dissemination of methods and data sets that provide climatological information to decision-makers in a variety of fields.

He is director of the Northeast Regional Climate Center, whose mission is to facilitate and enhance the collection, dissemination and use of climate data as well as to monitor and assess climatic conditions and impacts in the twelve-state, northeastern region of the United States.

"Those eligible for election to Fellow shall have made outstanding contributions to the atmospheric or related oceanic or hydrologic sciences or their applications during a substantial period of years," according to the AMS.

PENDERGRASS HONORED WITH TOP AMS EARLY CAREER AWARD

Angeline Pendergrass, assistant professor in the Department of Earth and Atmospheric Sciences, has been named the recipient of the 2023 Clarence Leroy Meisinger Award, one of the top Early Career Awards by the American Meteorological Society.

Pendergrass was honored "for original insights into the processes associated with precipitation variability and extremes and envisioned changes in variability due to global warming."

Pendergrass's research focuses on extreme precipitation and its response to climate variability and change. She studies extreme precipitation and its change holistically, at planetary scales and in the context of the distribution of precipitation in intensity, space, and time. Her research is grounded in a top-down approach that considers fundamental questions about precipitation and its change.

The Clarence Leroy Meisinger Award is given to an individual in recognition of research achievement that concerns the observation, theory and modeling of atmospheric motions on all scales. This scope includes the dynamical explanation of either contemporary climate patterns with their anomalous fluctuations or long-term climate changes and trends.

Angeline Pendergrass, assistant professor in the Department of Earth and Atmospheric Sciences.

MARK WYSOCKI RECEIVES CALS CAREER TEACHING AWARD

By Patrick Gillespie

Mark Wysocki, a stalwart of the atmospheric sciences program at Cornell, has been selected as this year's recipient of the Louis and Edith Edgerton Career Teaching Award.

"This is the highest teaching award in the College of Agriculture and Life Sciences," said Geoffrey Abers, chair of the Department of Earth and Atmospheric Sciences. "It honors a lifetime achievement in providing outstanding teaching and advising students. Mark clearly exemplifies commitment to students over his career; the honor is very deserved."

The Edgerton Career Teaching Award is the College of Agriculture and Life Sciences' premier teaching award as it honors a meritorious faculty member of the college who has provided outstanding teaching and advising to students throughout their long and continuous career in CALS.

"Although one person is being recognized, there are many who contributed to this award, especially the students," said Wysocki, senior lecturer in meteorology in the Department of Earth and Atmospheric Sciences.

Wysocki joined the CALS faculty in 1988. He received his Bachelor of Science in astronomy and physics from the University of Arizona in 1976 and a Master of Science in meteorology from Cornell University in 1988.

His main interest lies in teaching, with an emphasis on the practical applications of meteorological concepts. Wysocki is responsible for classroom instruction in 10 courses for science and non-science majors, and he is the state climatologist for New York.

"When I got to Cornell, I knew I would be learning from some of the best professors in the country, but I didn't know they would soon become mentors and friends," said Elisa Raffa '15, meteorologist and climate journalist for Queen City News/ FOX Charlotte in North Carolina. "There is truly no limit to the amount of good I can say about Mr. Wysocki. I would not be where I am today without him. As a student, Mr. Wysocki taught us all the basics of the atmosphere, and I still use my binders of notes in my professional career, nearly 10 years later."

"In addition to his fun and insightful lectures as well as his world-class expertise in weather and climate, Wysocki is always, always there for his students," said Joseph Lee '14, a data scientist at E Source, a consulting company for electric utilities. "His office door is always open, and students would go in and ask him questions all the time, sometimes forming a short line outside his office. Wysocki was my undergraduate thesis adviser, which helped start my research career. Back then, Wysocki and I had long, fruitful discussions on my undergraduate research project. His guidance was essential and invaluable for a young researcher like me."

"The review committee was very impressed with Mark's efforts in support of teaching and learning in the college and his commitment to students," said Sue Merkel, recently retired director of CALS' Office of Curriculum Development and Instructional Support. "This award could not have gone to a more deserving individual, and we are thrilled to be able to acknowledge Mark's contributions."

Wysocki has received the 2001 SUNY Chancellor's Award for Excellence in Teaching, the 2011 Kendal S. Carpenter Memorial Advising Award, the Professor of Merit for 2015, and the 2017 Edward N. Lorenz Teaching Excellence Award from the American Meteorological Society. He also has been recognized with the Merrill Presidential Scholar Outstanding Educator Award three times.

INVESTIGATING WATER'S ROLE IN SHAPING LANDSCAPES AND ECOSYSTEMS

Nicole Fernandez joined the EAS faculty in January 2022 as an assistant professor.

Nicole Fernandez joined the EAS faculty in January 2022 as an assistant professor. A recipient of the Provost's Faculty Postdoctoral Fellowship, she has pursued research in France as a visiting scientist at the Institut Polytechnique de Bordeaux, ENSEGID prior to coming to Ithaca. Nicole holds a B.A. in Earth sciences from Boston University and a Ph.D. in geology from the University of Illinois at Urbana-Champaign.

Research Summary

My research as a biogeochemist focuses on describing the variety of near-surface water-rock interactions that shape our landscapes, generate our water quality, and drive global cycling of elements important in regulating Earth's climate. Studying how water travels and interacts with its surrounding media in the subsurface beneath our feet is a difficult undertaking because we can't get any direct access to it through non-intrusive means.

What inspired you to pursue a career in this field?

Coming from a chemistry background in college, I found myself drawn to the complexity of the Earth's surface—the ultimate reactor—governed by an incredible ensemble of chemical reactions, shifting, and evolving across scales from the atomic to the ocean or our largest river basins and over geologic timescales. It's the equivalent of a physicist looking up at the cosmos and being awestruck by the sheer diversity of galaxies, stars, and planets that make up our universe. Unpacking the fundamental threads that shape the Earth's surface is daunting—each piece of the puzzle you could spend an entire lifetime or hundreds of lifetimes trying to solve. Yet, for me it's this challenge that makes the field so captivating. I am constantly humbled by how much I don't know and always find myself learning something new. I love the comradery of my field, the collaborative and interdisciplinary nature of the work, that requires a team effort to tackle such large problems. I also deeply appreciated the diversity of problems and systems you can explore. At any given moment, you can switch from a project looking at small watersheds to large sedimentary basins, hydrothermal systems to sediment deposition in the ocean, or urban environments. There is never a boring day!

Being Hispanic and part of the LBGTQ community, I have encountered many hurdles along my academic journey. I would never have been able to navigate this path alone without the support and guidance of family, friends, and mentors. From my parents who always provided unconditional love and confidence in my choices regardless of how foreign the idea of graduate school seemed to them; to my high school and my mentors there who lit my passion for science and played such a prominent role in my development; to my college mentors and the URM undergraduate research program I was fortunate to be a part of at Stanford University (SURGE). Through this incredible support system every mountain to overcome became a speed bump—for that I am forever grateful. They are always a constant inspiration for me to pursue this career and I largely credit them for even having this opportunity to do research and education as a living.

What are you most looking forward to as a Cornell Engineering faculty member?

As a Cornell Engineering faculty member, I am most looking forward to learning from and having the opportunity to collaborate with our faculty who are some of the most prominent minds in their respective fields. It's really a privilege in this regard to come to work every day and be surrounded by such amazing faculty.

On a similar note, I am both thrilled and a bit anxious about being a teacher and mentor to students. I, along with most of the faculty here, have an insatiable passion for learning and I hope to be able to transmit that to my students. With the challenges that currently face us as a society such as climate change, water quality and sustainability, land use and cover changes, and other anthropogenic forcing modifying the Earth surface system, I feel a strong responsibility to ensure that my students are trained appropriately and are equipped with the necessary tools to confront their future. I embrace the opportunity to be a mentor and pay forward all the mentorship and support I received along my journey to those just starting theirs. Being part of a student's success is one of the most rewarding aspects of being a professor.

Incoming Assistant Professors: July 2023

Grace Barcheck

Riley Culberg

RESEARCH SPOTLIGHT

Dan Dichek/ Cornell University

EXPLORING ANTARCTICA'S DEPTHS IN PREPARATION FOR SOMETHING BIGGER

By Patrick Gillespie

Shortly after arriving in Ithaca from Atlanta, Britney Schmidt gathered her research team and packed up their equipment and headed south. Way south!

Schmidt, an associate professor with a dual appointment in Cornell Engineering's Department of Earth and Atmospheric Sciences and the College of Arts & Science's Department of Astronomy, joined the Cornell faculty in July 2021 after spending nearly eight years at the Georgia Institute of Technology.

Less than three weeks into her first semester on the East Hill, Schmidt packed up her things and headed out for Antarctica. And while those in Ithaca were enjoying another spectacular autumn in the Finger Lakes, it wasn't so easy for Schmidt and her team.

After leaving the U.S. on September 17, the team had a longer-than-usual layover in New Zealand due to COVID protocols. Because their work was partially sponsored by Antarctica New Zealand and involved working with New Zealand colleagues, Schmidt's team would have to live and work out of the agency's Scott Base for the first time.

"It was a hard season because of the length and COVID," Schmidt said. "We had a 25-day quarantine; for most of the season we couldn't even go to the U.S. base."

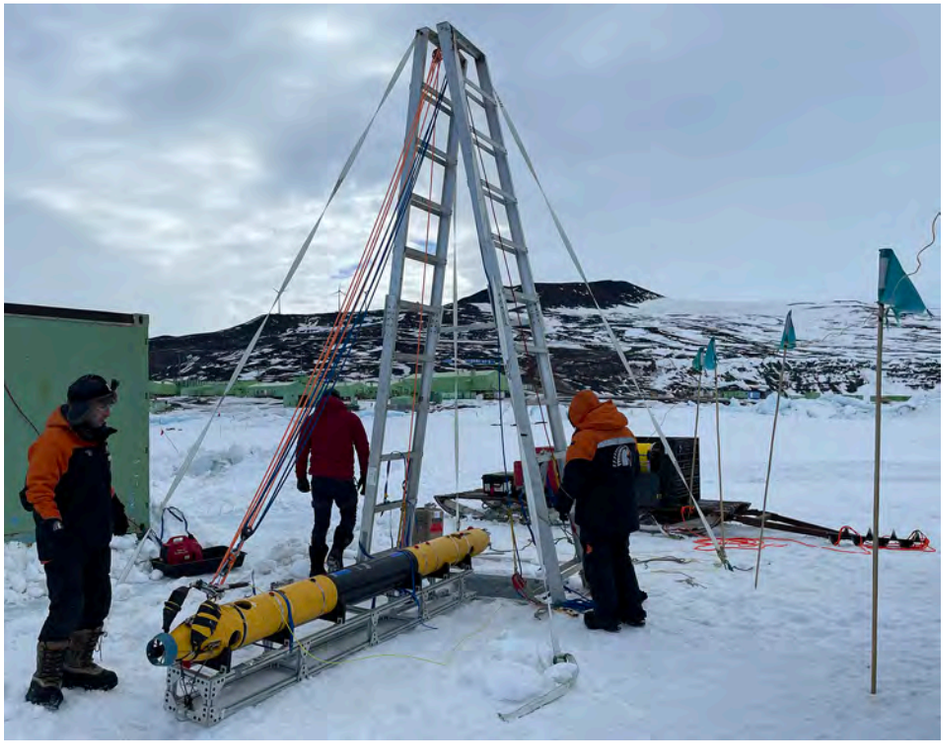
But once in Antarctica, the research team had plenty of work to do. First and foremost was exploring the confluence of glaciers, floating ice shelves and the ocean. To accomplish this, the researchers used Icefin—a slender, long-range, deep-water, under-ice, robotic oceanographer. The submarine robot was initially developed using Schmidt's startup funds at Georgia Tech, but since 2016 has been fully developed by Schmidt's team with grants coming from NASA, the National Science Foundation, Antarctica New Zealand and the Marsden program. Now, Icefin has moved to Cornell.

Schmidt's team focuses on how ice and oceans work across the solar system, including Earth.

"Particularly, we focus on Europa, the innermost icy moon of Jupiter," she says.

Europa is the best place beyond Earth to look for life in the solar

Britney Schmidt/ Cornell University



Britney Schmidt/Cornell University

system, Schmidt says.

And to prepare for eventual missions to Europa and other ocean worlds, Schmidt and her team are studying polar ice and climate here on Earth.

"We're trying to explore underwater, under ice, the hardest environment you can image—the most like Europa," said Schmidt.

And how does a research team explore under the ice of Antarctica? Schmidt and her team cart the modular, 13-foot long, torpedo-like Icefin around the continent, deploying the robot through the ice to characterize sub-ice environments using cameras, sonar, chemical and biological sensors to explore conditions around and beneath sea ice and ice shelves.

For work close to Scott Base and McMurdo Station, the team uses a drill similar to an ice fishing auger to get through the 2-5 meter thick sea ice. However, farther afield the robot must go through much deeper holes drilled using high pressure hot water in order to get under the ice, which can reach more than 700 meters (nearly 2,300 feet or almost half a mile). They then load Icefin onto its 16-foot-high frame and launch it through the ice shelf.

"We developed this tool to get into environments that have never been observed before," says Schmidt. "It allows us to make transects under the ice and measure the ocean directly where it's interacting with the ice."

During this most recent exploration, the team deployed a new sensor onboard Icefin under the sea ice near New Zealand's Scott Base. The sensor made it possible to understand ice shelf melting and sea ice physics in new ways.

From there, the team flew to a new location with New Zealand's Antarctic Science Platform program. There, the robot explored a subglacial channel that connects lakes and streams under the Antarctic ice sheet with the open ocean underneath the Ross Ice Shelf, the largest ice shelf on Earth (nearly the size of France).

"We dropped the robot straight into the channel where there was water rushing out from beneath the ice sheet," Schmidt said. "That has never been done before. It allowed us to see what was happening with the entire hydrology of Antarctica. It's exciting, looking at the interactions between the water beneath the ice and the ocean."

And if that five-plus month exploration (including quarantine) wasn't exhausting enough, Schmidt had little time to rest once she got back to Ithaca.

"I got back the first of March and began co-teaching ASTRO 1102, Our Solar System with Nikole Lewis, [assistant professor of astronomy (A&S)]" said Schmidt.

Looking at future research trips to Antarctica, Schmidt says she and her team have been invited by a group from Norway for a four-month exploration in 2023. They are also working on the fourth generation of Icefin and writing new proposals to understand the Earth and other planets.

"WE'RE TRYING TO EXPLORE UNDERWATER, UNDER ICE, THE HARDEST ENVIRONMENT YOU CAN IMAGE—THE MOST LIKE EUROPA."

— Britney Schmidt

RESEARCH SPOTLIGHT

CORNELL LEADS EXPANSION OF JICAMARCA RADAR OBSERVATORY

By Syl Kacapyr

Cornell is renewing and expanding research operations at the Jicamarca Observatory—the world's largest incoherent scatter radar system—thanks to more than $12 million in grants that will help scientists better understand the "space weather" that affects satellites and other technology linked to Earth's upper atmosphere.

Located in Lima, Peru, Jicamarca employs more than 18,000 dipole antennae spread across 90,000 square meters of desert terrain to beam radio signals toward space and gather valuable information about the Earth's ionosphere and beyond.

Cornell has led research operations for most of the observatory's existence, dating back to the 1960s when NASA began sending people to space and scientists wanted to learn more about the physics of space weather, disturbances caused by bursts of radiation hurled toward Earth by solar flares.

"That impetus has never really gone away because we keep putting more and more stuff up into space, including satellites that enable GPS, imaging, internet, and radio and television communications," said David Hysell, director of Jicamarca and the Thomas R. Briggs Professor in Engineering in the Department of Earth and Atmospheric Sciences. "Space is a hostile environment and as the solar flux climbs, people are going to be reminded that these operational systems are fragile and aren't resilient to space weather effects."

The National Science Foundation recently awarded Jicamarca $8.65 million to continue operations for the next five years, and an additional $1.25 million for facility upgrades set to begin in 2023. The upgrades will allow perpetual high-power mode operations at the facility and increase its radar sensitivity.

More than 18,000 dipole radio antennae help make up the Jicamarca Observatory in Lima, Peru. / Alastair Philip Wiper.

"It will be possible to measure atmospheric parameters way out into the plasmasphere. That's an order of magnitude further away than any other radar facility is making observations right now," said Hysell, who added that the radar signals will be powerful enough to penetrate the surface of the moon, helping scientists search for water and other lunar discoveries.

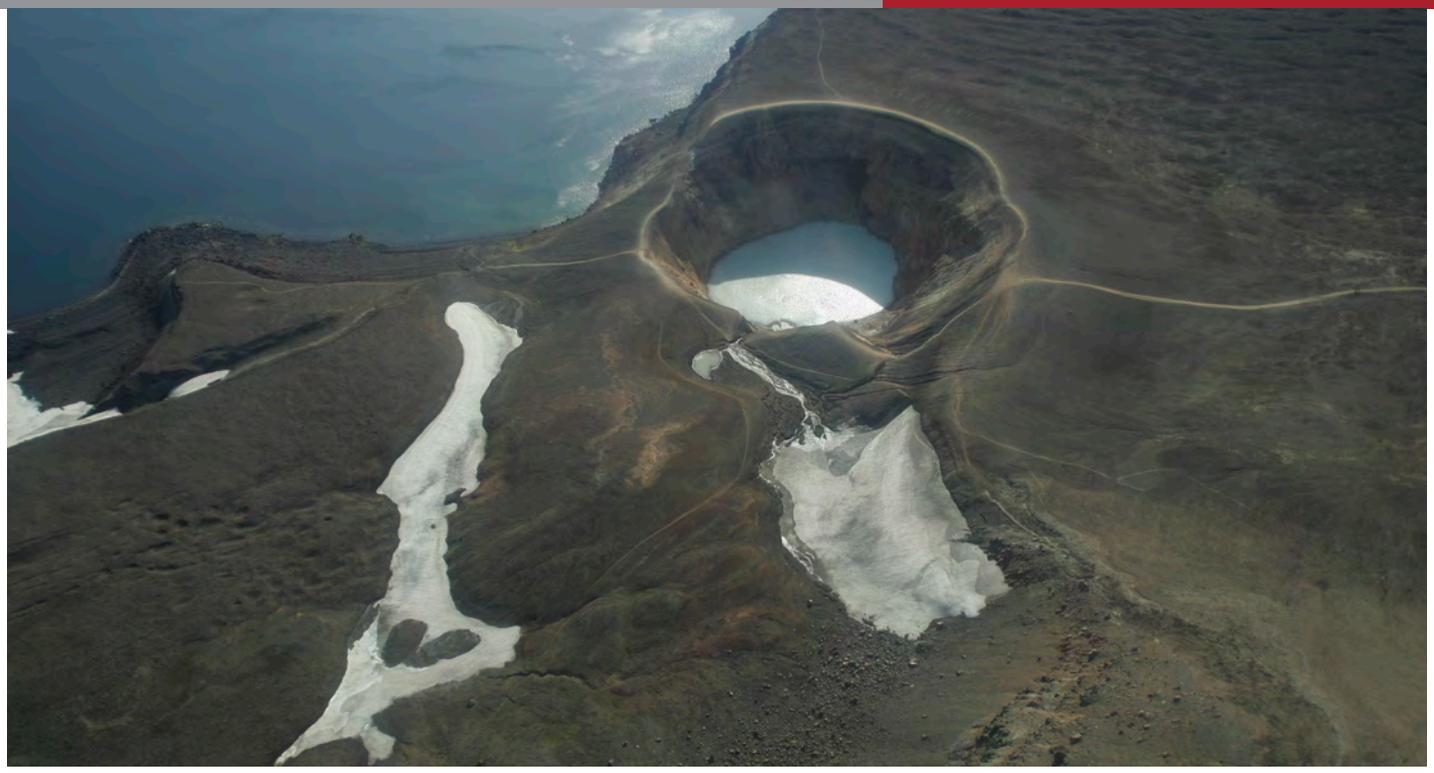
Hysell hopes the upgrades may even be strong enough to bounce signals off the solar corona, the outermost region of the sun's atmosphere—something no other radar facility has been able to do, according to Hysell. If successful, the technology could provide the basis for an entirely new level of space weather forecasting.

A $2.8 million grant from the National Science Foundation's Major Research Instrumentation Program will provide further upgrades to the observatory, allowing it to construct and deploy two new radio array facilities in Peru. The new facilities will work in concert with Jicamarca's existing array, creating a triangulation effect that will allow the observatory to perform 3D volumetric imaging.

Hysell said the grant—led by Fabiano Rodrigues, Ph.D. '08, now an assistant professor of physics at the University of Texas, Dallas—will enable several research projects that target scientific mysteries in the ionosphere. One such project will examine meteor radar afterglow, the radio waves emitted by meteors.

"This is a really new, exciting phenomenon," Hysell said. "Our radar can actually see the little rock, that micrometeorite, that left the trail and it can scatter off the ionization behind it. Then the new facilities will see the radio emissions from it. It's really cutting edge."

All the upgrades are expected to be completed by the end of 2023.



DETERMINING RATE OF MAGMA INJECTION MAY LEAD TO MORE RELIABLE VOLCANIC FORECASTING

By: Patrick Gillespie

Forecasting volcanic eruptions has been spotty at best due mostly to the inability to identify reliable eruptive precursors. But a group of researchers at Cornell University's College of Engineering, Roma Tre University and the University of Leeds may have found a solution to that problem.

The research team addresses this limitation in a scientific article published in Nature Geoscience, showing that a novel parameter, which can be indirectly measured at volcanoes, is a good indicator of whether it will go on to erupt or not.

"This precursor is the rate of magma injection within the volcano in the weeks to months before the eruption, derived from measurements of surface deformation from satellites," said Federico Galetto, a postdoctural research associate in Cornell's Department of Earth and Atmospheric Sciences. "The approach has been tested in some highly-active and frequently erupting type of volcanoes, those with calderas, which are wide volcanic depressions at the surface formed in the past by the partial emptying of the magma chamber below."

In particular, Galetto says, the precursor has been tested at calderas that erupt a very common type of magma known as "basalt".

Forecasting eruptions is the main challenge for volcanology, as ultimately it can reduce the impact of volcanic activity on the population and environment. Volcanology has experienced some success in forecasting eruptions on short timescales of hours to days beforehand. Nevertheless, these timescales may be too short for appropriate mitigation measures, including the evacuation of the population, especially in densely populated areas.

"Ideally, volcanologists would issue reliable medium-term forecasting, on a timescale of weeks to months," to give authorities the opportunity to implement appropriate prevention plans, said Galetto.

The results of the research show that it is possible to successfully forecast eruption for 86% of the cases, which is far higher than hit rates currently obtained through any other parameter. In particular, if the rate of magma injection below the caldera is high, eruption occurs within one year in all the considered cases; conversely, if the magma injection rate is low, eruption does not occur for 86% of cases.

"This novel approach may also be applicable for other types of volcanoes, which would offer an exciting prospective in forecasting eruptions more generally," Galetto said. "As the rate of magma injection can be estimated from satellites in near-real-time for most volcanoes in the world, regardless of their location and accessibility, this may allow a widespread, prompt and remarkably early warning—weeks to months in advance—a crucial support when densely inhabited areas may need to be evacuated."

The research was published in Nature Geoscience on June 23 and the co-authors include Galetto, Valerio Acocella from Rome Tre University's Department of Science, Andrew Hooper from the University of Leeds' School of Earth and Environment and Marco Bagnardi, formerly from Leeds and now with NASA Goddard Space Flight Center; Greenbelt, MD.

FEATURE STORY

ADVANCING GEOTHERMAL EXPLORAT

EAS faculty explain what a nearly two-mile deep borehole means for

By Teresa Jordan & Patrick Fulton

Wanted: a carbon-free energy source with which to heat buildings in populated regions with cold winters.

That is the challenge being tackled by Cornell University as it assesses Earth Source Heat, a vision to heat campus using geothermal energy. A busy year of progress was powered by expertise and efforts within the Department of Earth & Atmospheric Sciences.

Throughout summer 2022, five EAS faculty members, five graduate students and five undergraduates—the students mostly affiliated with EAS—put their efforts to drilling and testing a geothermal exploration well on the Cornell campus. The Cornell University Borehole Observatory (CUBO) was drilled between June 21 and August 13 to a depth of 9,790.5 feet (2,984 meters) and then probed and tested between August 13-21. Monitoring of local seismic activity and surface and shallow ground water that had begun a few years in advance persisted throughout the summer. Petrology, stratigraphy, hydrogeology, seismology, thermal geophysics, aqueous geochemistry, petrophysics: the earth science topics involved daily in the CUBO project read like a catalog of geosciences subdisciplines and drew EAS students and faculty into the heart of a university-wide team working toward Cornell's sustainable energy transition.

CUBO was funded in large part by a U.S. Department of Energy (DOE) contract, led by Professors Jeff Tester (Chemical & Biomolecular Engineering), Patrick Fulton (EAS) and Teresa Jordan (EAS), and integrally assisted by geologist J. Olaf Gustafson EAS Ph.D. '20. Cornell University's Facilities and Campus Services and central administration stepped in to fill the gap when inflation, supply chain and work to ensure community acceptance drove up the price tag. With the leadership and hands-on efforts of numerous staff well versed in Cornell Facilities' business and operational practices, partnering with faculty, the project succeeded.

CUBO faculty and students the day the drill mast was raised, shortly before drilling began. From left to right: Terry Jordan, Roberto Clairmont, Ivan Purwamaska, Daniela Pinilla, Reeby Puthur, Madeline Fresonke and Patrick Fulton.

Planning and Monitoring

CUBO was selected for DOE funding after a decade of studies of the potential for direct-use applications of geothermal heat in which Jordan, the J. Preston Levis Professor of Engineering Emeritus, and her students were central figures. That work provided a firm grasp on what to expect of the sedimentary rocks and heat below Cornell's campus but lacked any firm data for the basement rocks or for the capacity of the rocks to transmit water, an absolute key to extracting heat from the rocks. The background information allowed design of a well with a diameter and structure of steel casing that would be adequate to provide the missing data and later function as an observatory.

Fulton, an assistant professor and a Croll Sesquicentennial Fellow, was the faculty lead on the mechanical, hydrologic and thermal features of the design, which culminated in hydrologic and stress testing as the last step of CUBO's summer work. This fall Fulton will begin to monitor the subsurface conditions using a fiber optic cable that will monitor temperature throughout the borehole over time. Those data will reveal if and how fluids in the subsurface move naturally and, if more wells are drilled for the ESH project, how the subsurface responds to the activities conducted in those nearby wells.

Starting in 2015, EAS professors Kade Keranen, Larry Brown and Matt Pritchard had begun monitoring of background seismic activity in the Ithaca area, which led to installation of 15 seismograph stations. Supervised by Professor Geoff Abers, an independent firm submitted a weekly report on seismic activity within the network while CUBO was drilled, which was shared with the public. A few years in advance of drilling, Gustafson organized drilling and sampling of water monitoring wells around the future

RATION AT CORNELL UNIVERSITY

s for the future of the university.

CUBO borehole, and in 2022 began surface water monitoring of nearby creeks. Assistant Professor Nicole Fernandez oversaw the monitoring and analysis of creek samples while CUBO was drilling, as well as participating in the chemical assessment of water from CUBO sampled in the final steps of the summer project.

Drill Site Operations and Student Participation

Cornell contracted with Capuano Engineering Company for design and oversight of the construction of the observatory, Precision Drilling for the equipment and personnel to drill, and Schlumberger Well Services for services ranging from design and management of the drilling mud, to drill bits, cementing of casing, geophysical logging and much more. This set of companies brought dozens of seasoned professionals to the CUBO site at various times during the final steps of planning and execution and kept the operation always moving 24/7 on a staff of at least 10 people.

A key service line that operated full time was "mudlogging" — the monitoring and documentation of all the solids, liquids and gases that came out of the borehole. Mudlogging was staffed 24/7 by Cornell students, working as assistants to a professional Schlumberger mudlogger. The Capuano supervisor, the Precision drillers and the Schlumberger mud engineers relied on continual real-time reports from the mudloggers to adapt to changing rock and fluid properties, and the students learned from those professionals about career, life and the energy industry. The seven Cornell students on shifts — Sean Fulcher, Daniela Pinilla, Roberto Clairmont, Ivan Purwamaska, Juliette Torres, Madeline Fresonke and Reeby Purthur — had the messy job of catching the mud-drenched rock cuttings at the filtration system where the borehole mud was separated into two streams, rock waste and viscous fluid. The students cleaned the samples, catalogued them and assisted with several of the analysis steps.

Assistant Professor Nicole Fernandez with a bucket of water collected from the CUBO borehole during the final hydrological test.

EAS undergraduate Madeline Fresonke demonstrates the messy work of catching and cleaning samples of cuttings immediately after the borehole mud carries them out of the borehole.

Throughout the summer, EAS undergraduate Zach Katz reviewed the weekly seismograph data providing an initial quality control check. Summer student trainees Eric Negron Alvarez and George Scheibler collected and analyzed water samples and daily water quality measurements from Fall Creek and Cascadilla Creek.

Former Cornell EAS students also played much appreciated roles. Noteworthy cases were Tomás Zapata Ph.D. '89 and John Guffey M.Eng. '00, who used their professional networks and their personal experiences to help the CUBO project team to make sensible decisions and overcome challenges.

Public Interest and Outreach

CUBO was a tremendous opportunity for public education

about geology and what lies below everyone's feet because it was highly visible and because word of activities spread quickly across the community. Professor Jordan worked closely with experts in public education from the Ithaca community—Deborah Hoard of Photosynthesis Productions and Paleontological Research Institution's (PRI) education leaders Drs. Rob Ross and Don Haas—to produce and release a steady stream of daily progress reports and weekly explanations of the scientific and engineering steps. Faculty members Jordan, Fulton, Abers and Fernández were each featured in a series of weekly videos the Cornell's central communication unit released to inform the local community (https://EarthSourceHeat.cornell.edu). Graduate student Clairmont starred as one of two regular hosts in videos about CUBO developed by this educational outreach team (https://deepgeothermalheat.engineering.cornell.edu/), while graduate students Pinilla and Fulcher each took a turn as the Earth Source Heat weekly interviewee, describing well cuttings and the role of fractures in water flow, respectively.

Project scientist Patrick Fulton on the former spot of the CUBO drill rig. / Photo courtesy of PSP

An especially close connection to public curiosity was possible via a weekly "office hour" to which the community was invited, adjacent the CUBO fence with a great view of the action. Each week about 20 people came and peppered project staff members with questions. The reutilization of the educational materials created leading up to and during drilling for K-12 teacher education continues, led by our PRI collaborators.

Geological education and energy business education also turned inward at Cornell. Drilling a borehole is far outside of Cornell University's normal business practices. The facilities staff, most of whom are engineers or contracting specialists, picked up a lot of earth science knowledge as well as an understanding of the technical and financial risks embedded in the energy business.

Ongoing analysis and utilization of the new understanding in ESH analysis

The drill rig is gone and the camaraderie of "summer camp" at CUBO is a memory. Yet the work to maximize the value of the data from CUBO is intense. Supervised principally by Professor Fulton, geological sciences graduate students Pinilla, Clairmont, Fulcher and Purwamaska each is responsible for an initial research theme that is based on CUBO data: in situ stress, hydrogeology, fracture characterization and thermal conditions, respectively. Their efforts develop both a better fundamental understanding of subsurface behavior and provide vital input to ongoing evaluation of the next steps for Cornell's Earth Source Heat program.

EAS students Roberto Clairmont, Juliette Torres and Daniela Pinilla discussing steps to package and inventory CUBO rock cuttings.

The EAS CUBO Team

Faculty
Geoff Abers
Larry Brown
Patrick Fulton, Co-PI
Nicole Fernandez
Kade Keranen
Terry Jordan, Co-PI
Matt Pritchard

Alumni
John Guffey M.Eng. '00
J. Olaf Gustafson Ph.D. '20
Tomás Zapata Ph.D. '89

Graduate Students
Roberto Clairmont
Sean Fulcher
Daniela Pinilla
Ivan Purwamaska
Reeby Puthur (CBE)

Undergraduate Students
Eric Negron Alvarez
Madeline Fresonke
Zach Katz
George Scheibler
Juliette Torres

ALUMNI SPOTLIGHT

TOMAS ZAPATA PH.D. '95 CONNECTS DOTS **FOR CUBO SUCCESS**

By Reeve Hamilton

Meeting a goal as ambitious as Cornell's aspiration to achieve carbon neutrality by 2035 requires broad collaboration. For example, this summer's drilling of the Cornell University Borehole Observatory (CUBO), which opened up new opportunities for exploring geothermal energy, succeeded due to involvement from Cornell faculty, students, staff, and alumni like Tomás Zapata, Ph.D. '95, who works for the multi-energy company Repsol.

Nearly 10,000 feet deep, CUBO is an exploratory borehole designed to allow scientists to assess deep subsurface rock conditions and heat output. Their findings will inform if and how the university proceeds with implementing Earth Source Heat (ESH), Cornell's version of a deep geothermal system that would use the Earth's internal heat to warm the Ithaca campus without the use of fossil fuels.

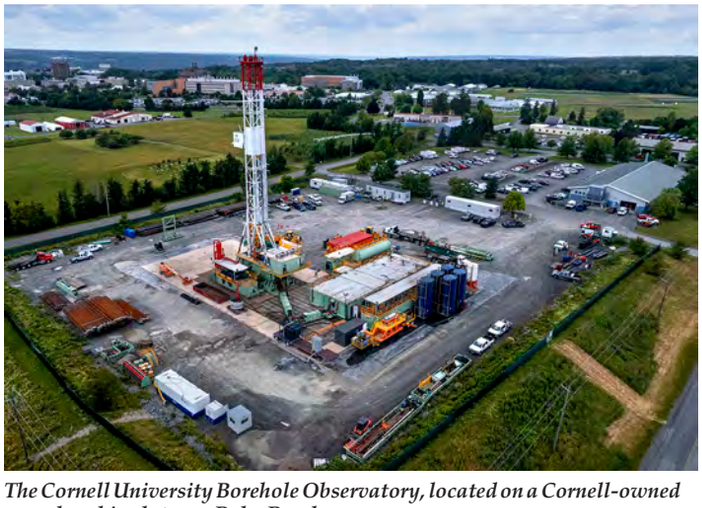
Throughout the project, the CUBO team needed advice from experts — on topics such as how to safely drill nearly two miles down and how to extract the necessary data from deep within the Earth — who were not financially connected to the contractors hired for CUBO's construction. Repeatedly, the team turned to Zapata and his colleagues at Repsol, a global multi-energy company with extensive technical expertise.

"Repsol is committed to a sustainable world, and we believe in a future founded on innovation" said Zapata, Repsol's Director of Exploration Americas Assets. "So, it is natural for us to develop collaborations with forward-thinking academic institutions like Cornell, which I happen to know well, as they execute renewable energy projects."

Along with Laszlo Benkovics, the company's New Green Ventures Senior Manager, Zapata helped establish a cooperation agreement between Repsol and Cornell that provided the CUBO team with access to Repsol's technical expertise throughout the drilling project. As a company committed to developing low-emissions energy alternatives, Repsol will be able to assess ESH as it moves forward and determine if it provides a scalable solution for renewable heating in cold-climate regions around the globe.

Zapata, Benkovics and several of their colleagues met with the faculty and staff involved in the CUBO before drilling began. They also sponsored technical training in their Houston corporate offices for three Cornell graduate students, who are now analyzing CUBO data. Benkovics's team remained in touch with the project leads throughout the summer, providing guidance and technical support.

"Being able to access Repsol's expertise throughout this CUBO process proved to be critical for our success," said Bert Bland, Cornell's Associate Vice President, Energy & Sustainability. "And of course, it has been great to have Tomas involved. It always helps to have more Cornellians in the mix."



The Cornell University Borehole Observatory, located on a Cornell-owned gravel parking lot near Palm Road.

Having received his Ph.D. from Cornell University in structural geology and tectonics, Zapata was particularly well-positioned to help connect the dots between what the university was trying to do with CUBO and the expertise of Benkovics and his team at Repsol.

Tomás Zapata Ph.D. '95

Since 1996, Zapata has conducted exploration activities working at Repsol, occupying different technical and managerial positions, throughout Latin America basins. He worked as a structural geology specialist for exploration study teams and published more than 40 papers on structural geology and tectonics of the Andes. He has occupied various managerial and executive positions at the company. In his current role, he manages Repsol's Exploration Business for Bolivia, Perú, Colombia, Guyana, Brazil, México and the U.S.

Zapata, who also has an undergraduate geology degree from Buenos Aires University, Argentina, where he worked as Assistant Professor from 2001 to 2011, was particularly glad to be involved in a project that has provided graduate students with meaningful experiential learning opportunities relating to renewable energy.

"The future career paths of engineers and geoscientists need to adapt as we make this major energy transition, which is what Cornell's ESH project is all about," Zapata said. "I am glad to see my alma mater leading the way in both innovating these technologies and creating learning opportunities to develop our future innovators."

ALUMNI NEWS

PAIR OF EAS ALUMNI TO BE HONORED AT CALS OUTSTANDING ALUMNI AND FACULTY AWARDS CEREMONY

A pair of EAS graduates have been selected to receive awards at the annual CALS Outstanding Alumni and Faculty Awards Banquet to be held November 18, 2022. Dr. Gretchen Goldman '06 will receive the Young Alumni Achievement Award, while John Toohey '84 is among the recipients of the CALS Outstanding Alumni Award.

Goldman is currently serving at the White House Office of Science and Technology Policy as the Assistant Director for Environmental Science, Engineering, Policy, and Justice. Previously, Dr. Goldman was the research director for the Center for Science and Democracy at the Union of Concerned Scientists.

For more than a decade, Dr. Goldman has led research and communications efforts at the nexus of science and policy on topics ranging from air pollution health standards, federal scientific integrity, climate policy, and environmental justice. Dr. Goldman has testified before Congress and sat on the board of the nonprofit 500 Women Scientists. Her words and voice have appeared in Science, Nature, The New York Times, The Washington Post, CNN, NPR, and the BBC, among others. Dr. Goldman holds a Ph.D. and M.S. in environmental engineering from the Georgia Institute of Technology, and a B.S. in atmospheric science from Cornell University.

She currently serves on the advisory council for Cornell's Department of Earth and Atmospheric Sciences. Previously, she served as vice president of the Cornell Atlanta Alumni Association and volunteered with the Cornell Alumni Admissions Ambassador Network and Cornell externship program.

"Getting into Cornell was my wildest dream. I was elated to attend, and I spent the next four years learning and experiencing as much as I could," Goldman said. "Outside of the classroom, my Cornell experience was just as valuable for my future pursuits. I learned leadership, management, and facilitation skills through Cornell Outdoor Education, the CALS Ambassadors program, and the Cornell Chapter of the American Meteorological Society. I learned to be a research scientist at the Northeast Regional Climate Center on the 11th floor of Bradfield Hall.

Dr. Gretchen Goldman '06

John Toohey '84

"Importantly, Cornell taught me the value of service and using your skills to better the world. I took this lesson to heart and spent a decade at the nonprofit Union of Concerned Scientists, fighting for a healthier planet and a safer world," said Goldman.

Toohey, known on TV as John Morales, is an atmospheric and environmental scientist with a long tenure as a widely respected broadcast meteorologist. He also founded and is the lead certified consulting meteorologist at ClimaData, a boutique firm specializing in forensic meteorology and weather consulting.

During his 38-year career, Toohey-Morales has been proud to participate in the public, academic, and private sectors of America's Weather Enterprise. Even though he retired this year from Florida's legacy television station, NBC-owned WTVJ Channel 6 in Miami, he still functions as their first-ever hurricane specialist. John is also an influential climate communicator with a following in the hundreds of thousands on social media, and a climate change columnist for the Bulletin of the Atomic Scientists. John was elected Fellow of the American Meteorological Society and was inducted into the National Academy of Television Arts & Sciences Silver Circle for exceptional and exemplary contributions in broadcasting for over 25 years.

At Cornell, John serves on the Atkinson Center for Sustainability's external advisory board, the CALS Advisory Board, the Cornell University Council, and is the president of his Cornell Class of 1984.

Toohey-Morales graduated from the College of Agriculture and Life Sciences as an atmospheric scientist in 1984. Extracurriculars on and off campus included the Cornell crew, WVBR and countless afterschool hours at Bradfield Hall trying to win the student weather forecasting contest.

"I knew I loved Cornell from the moment I saw it. But never could I have imagined that Cornell would love me back," said Toohey. "One of my greatest honors was being asked to serve this great institution. And now, I'm humbled to be recognized as an outstanding College of Agriculture and Life Sciences alumnus."

EAS OUTREACH

SUMMER INTERNSHIPS AIM TO INCREASE DIVERSITY IN GEOSCIENCES

By Eric Laine

The National Science Foundation has awarded funding for a new program of paid summer internships in the Department of Earth and Atmospheric Sciences (EAS) intended to draw students from diverse backgrounds to pursue graduate degrees in the field of geosciences.

The program, known as the Cornell Geopaths Geoscience Learning Ecosystem (CorGGLE), will develop a geoscience learning ecosystem for students and recent graduates from non-geoscience fields to explore opportunities for geoscience graduate study, specifically giving them exposure to socially relevant careers in atmospheric and geological sciences.

Over the course of nine weeks during the summer, students conducted research with EAS faculty mentors and consulted with EAS alumni about careers in geoscience that have the potential to impact socially relevant issues like energy resources, extreme weather and climate change.

Cornell EAS worked with the office of Diversity Programs in Engineering to develop partnerships with universities such as historically Black colleges and universities and minority serving institutions.

"Our goal is to bring more people from more diverse backgrounds into the field," said Matthew Pritchard, professor of earth and atmospheric science and CorGGLE lead. "We know students are not just interested in salaries and career opportunities; they want to work on problems with societal relevance."

The summer internships offered a stipend, housing and travel accommodations, but most importantly students will get an opportunity to develop, research and present an impactful research project with distinguished EAS faculty and alumni mentors.

The CorGGLE project has partnered with five institutions in the mid-Atlantic region that have diverse undergraduate student populations with strong backgrounds in science, technology, engineering and mathematics that are under-represented at Cornell: Hunter College of CUNY, whose undergraduates are majority women; State University of New York at Oneonta, a rural institution with a large percentage of underrepresented minorities and first-generation college students; Rutgers University in Newark, New Jersey, which has been ranked as the most diverse research university in the nation by U.S. News & World Report for 18 consecutive years; Bennett College in Greensboro, North Carolina, one of only two historically Black colleges for women in the U.S.; and Morgan State University in Baltimore, Maryland, the Preeminent Public Urban Research University.

"As a CorGGLE collaborator, we are leveraging our networks with key scholar programs like the Ronald E. McNair Scholars, Louis Stokes Alliances for Minority Participation, Meyerhoff Scholars, and the GEM Consortium to attract STEM students from historically minoritized backgrounds," said Jami P. Joyner, former director of Diversity Programs. "This effort adds momentum for us to continue strengthening and expanding our networks across minority serving institutions."

CorGGLE and other EAS summer interns take a selfie after lunch together with CorGGLE graduate student co-coordinators Andie Gomez-Patrón and Olivia Paschall.

In addition to drawing from under-represented student populations, the CorGGLE team looks to capitalize on the multidisciplinary nature of geosciences to diversify the EAS graduate student cohort. "In my own group," Pritchard said, "we've had computer scientists, electrical engineers, physicists, as well as different types of geoscientists. We're taking the tools from individual disciplines and applying them to study problems in the earth and atmospheric sciences, whether it be climate change, or natural hazards or water quality."

Joyner also emphasized the project's cross-discipline advantages. "CorGGLE's strategic approach is an excellent framework that aptly demonstrates the applied impact of interdisciplinary diversity coupled with compositional inclusion."

In addition to Pritchard and Joyner, the CorGGLE team includes several faculty members from Cornell EAS who will develop projects with the student participants based on their research expertise, including Art DeGaetano, professor and director of the Northeast Regional Climate Center; Kade Keranen, associate professor who teaches environmental and field geophysics classes; Natalie Mahowald, the Irving Porter Church Professor of Atmospheric Sciences; Karin Olson-Hoal, the Wold Family Professor in Environmental Balance for Human Sustainability; Teresa Jordan, the J. Preston Levis Professor Emerita of Geological Sciences; Patrick Fulton, assistant professor and Croll Sesquicentennial Fellow; Rowena Lohman, professor of geophysics and remote sensing; and assistant professor Megan Holycross.

EAS AWARDS & HONORS

FACULTY

Bill White, received the H.C. Urey Award, which is bestowed annually by the EAG for outstanding contributions advancing geochemistry over a career. It is named in honor of Harold Clayton Urey, an American physical chemist whose pioneering work on isotopes earned him the Nobel Prize in Chemistry in 1934 and later led him to theories of planetary evolution.

White is a pioneer who shaped our understanding of chemical geodynamics of the deep Earth. He has made several fundamental contributions in many areas of geochemistry, but especially to our understanding of geochemical architecture of the mantle, the nature of crustal recycling into the mantle and the evolution of the mantle-crust system. White is also well known for authoring the two most widely used textbooks on geochemistry and isotope geochemistry. Through the generous sharing of his ideas, his influence goes far beyond his publications and permeates all of geochemistry and Earth science.

The 2022 Urey Award Lecture was be presented at the Goldschmidt2022 Conference in Hawai'i.

Art DeGaetano, professor and Director of Undergraduate Studies for Atmospheric Sciences, has been named a Fellow by the American Meteorological Society, an honor awarded to no more than 0.2% of the membership each year.

Angie Pendergrass, assistant professor, is this year's (2023) winner of the Clarence Leroy Meisinger Award, the top early-career award of the American Meteorological Society. Angie was also the recipient of a 2022 Outstanding Early Career Award presented by the American Meteorological Society (AMS) Scientific and Technological Activities Commission (STAC). The award recognizes Pendergrass' fundamental contributions to understanding the dynamics of extreme precipitation and its response to greenhouse gas forcing, the radiative forcing caused by greenhouse gases that humans emit.

Rowena Lohman, has been promoted to full Professor, effective July 1, 2022.

Esteban Gazel, was named the Charles N. Mellowes Professor of Engineering, effective July 1, 2022.

Terry Jordan, announced her retirement after July 15 from the regular faculty and will assume an Emerita title thenceforth. Terry's impact on the department has been significant both through her scientific contributions and her institutional leadership and is much appreciated.

Toby Ault, is resuming as Director of Graduate Studies for Atmospheric Sciences, for another term.

Matt Pritchard, was re-elected to another term as INSTOC Director. The INstitute for STudy Of Continents has a storied history at Cornell. Most recently, under Matt's leadership INSTOC held a very exciting two-day symposium in 2019 on Mysteries of the Earth's Mantle, honoring Larry Cathles, Bob Kay and Bill White.

Sara Pryor, receive an Energy Systems Integration Group (ESIG) Excellence Award at the ESIG Spring Workshop in Tucson, AZ. The award is given for engineering and scientific contributions to the understanding of climate change impact on wind energy resources. Pryor was also appointed an Affiliate Professor in the Department of Wind Energy at the Danish Technical University. Pryor has been reappointed for another three-year term as Faculty Senator representing EAS.

Mark Wysocki, was selected as this year's recipient of the Louis and Edith Edgerton Career Teaching Award. The Edgerton Career Teaching Award is the College of Agriculture and Life Sciences' premier teaching award as it honors a meritorious faculty member of the college who has provided outstanding teaching and advising to students throughout their long and continuous career in CALS.

STUDENTS

CORNELL AWARDS

Meyer Bender '29 and Stephen Bender '58 Memorial Scholarship

Established in 1981 by the Bender family in honor of Meyer Bender '29, who was one of the most generous and innovative benefactors to the department. The scholarship now also honors Meyer's son, Stephen Bender '58.

Award Recipient: Patricia MacQueen, doctoral student in geological sciences.

Bryan Isacks Excellence in Teaching Award

Established in 2007 by the late Timothy Dubbels '93 in honor of Professor Bryan Isacks to recognize a graduate student who is highly effective as a teaching assistant.

Award Recipient: Kyle Dayton, doctoral student in geological sciences.

Outstanding CALS Graduate Teaching Award

THis award is in recognition of the student's superior performance and important contribution in the instructional program of the college.

Award Recipient: Jaleigh Pier, doctoral student in geological sciences.

Michael W. Mitchell Memorial Fund

Awarded to outstanding juniors or seniors majoring in E and atmospheric sciences. The award is given to a "geology student who proves themselves adept at other liberal arts fields as well as geology—a student of the world."

Award Recipients: Ava Kiss '22, Auden Reid-McLaughlin '22, Josh Sayre '22, Aiden Thomas '23.

Chester Buchanan Memorial Award

Presented each year to "that outstanding senior majoring in geology," as recommended by the department faculty.

Award Recipient: Kiera Crowley '22.

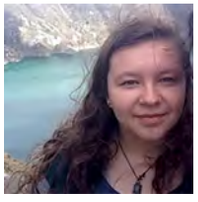
Frank H. T. Rhodes Award

Awarded each year to a senior with the highest grade point average in the Earth and atmospheric sciences major.

Award Recipient: Kiera Crowley '22.

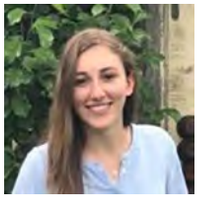
EXTERNAL AWARDS

Julianna Christopoulos '22, was awarded an Outstanding Student Oral Presentation Award from the American Meteorological Society's 24th Conference on Atmospheric Chemistry for her research, "Effects of the 2020 Gigafire on Tropospheric Ozone Chemistry in the United States."



Andie Gomez-Patron, received a National Science Foundation Graduate Research Fellowship. Gomez-Patron, who earned her bachelor's degree from Northwestern University, works with Matt Pritchard, Professor and Director of Graduate Studies for Geological Science.

Sara Miller, has been awarded a 2022 Future Investigators in NASA Earth and Space Science and Technology (FINESST) Fellowship to study the fluid dynamics of the ocean at Jupiter's moon, Europa. Miller, who is studying under Associate Professor Britney Schmidt, also found out earlier this summer that she was one of 30 women across the globe selected for a 2022 Zonta International Amelia Earhart Fellowship, which brings a $10,000 award.



Sam Moruzzi '20, had her proposal to study the geophysical evolution of Pluto accepted by NASA FINESST. Moruzzi is currently a graduate research assistant with the University of Arizona.

Olivia Paschall, received a National Science Foundation Graduate Research Fellowship. Paschall, who received her undergraduate degree from Appalachian State University in Boone, NC, is studying under Associate Professor Rowena Lohman.

Kayla Russo, received a National Science Foundation Graduate Research Fellowship. Russo, who will be working with Assistant Professor Nicole Fernandez, is a graduate of the College of Coastal Georgia in Brunswick.

STUDENT PROFILE

SARA MILLER: IS THERE **LIFE IN EUROPA'S OCEAN?**

By Chris Dawson

If you were going to look for life elsewhere in our solar system, where would you look?

For most of us, this is a purely hypothetical question. But not for Sara Miller. Miller, who is a doctoral student in the lab of Associate Professor Britney Schmidt in Cornell's Department of Earth and Atmospheric Sciences (EAS), has her eyes set firmly on Jupiter's moon Europa.

There is a preponderance of evidence that life on Earth began in the oceans, so Miller and many planetary scientists believe that in our search for life outside of Earth, it would be worthwhile to explore extraterrestrial oceans as soon as we are technologically able. Beneath its global ice shell, Europa hosts one of the most promising oceans for exploration beyond Earth. Combining information beamed back to Earth from NASA's Galileo mission in the 1990s with observations from ground-based telescopes on Earth, experts are fairly confident that Europa's frozen shell is made of water ice, and that under the ice is an ocean of salty, liquid water surrounding the entire moon at depths of 40 to 100 miles.

Miller's path to becoming a planetary scientist has roots in her childhood. Her grandfather was a fighter pilot and his experiences inspired Miller and her brother to dream of exploring air and space, giving way to what their family referred to as the "Miller family space race." Miller would go into aerospace engineering while her brother went to the U.S. Air Force Academy and became a pilot. As a junior in high school Miller had an internship at NASA's Johnson Space Center in Houston and this led her to Georgia Tech, where she completed her undergraduate and Master's degrees in aerospace engineering.

Miller had every intention of continuing on to a Ph.D. in the same field, but then took an elective course with Georgia Tech faculty member (and Cornell alumni) Professor James Wray '10. Wray is a planetary scientist who has been involved in several NASA missions to Mars. Miller greatly enjoyed the class. One day she went to Wray's office hours and in the course of their conversation said how deeply she wished she had known the field of planetary science existed as she was choosing a Ph.D. program.

Wray responded by asking Miller how old she was—which was 25 at the time—and then said the words that changed her life: "If 25 is too late for you to change your mind and change your major, then God help the rest of us."

Miller took his words to heart, was introduced to Britney Schmidt, switched majors, and in August of 2021 moved to Ithaca to continue working with Schmidt in her new lab at Cornell. Schmidt's team studies Earth's glaciers and ice shelves and the oceans beneath them in an effort to better understand

“OCEAN DYNAMICS ARE A KEY FOR LIFE ON EARTH. SO IN THE SEARCH FOR LIFE BEYOND EARTH IN ASTROBIOLOGY, UNDERSTANDING THE FLUID DYNAMICS OF HOW THOSE OCEAN WORLDS LIKE EUROPA WORK IS A REALLY INTERESTING PROBLEM TO LOOK AT.”

— Sara Miller

Europe, the water ice moon with subsurface oceans. / Dreamstime.com

what conditions may exist beneath Europa’s ice. Miller’s role in this work is to use her deep knowledge of fluid dynamics to mathematically model ocean circulation and ice-ocean interactions for icy moons like Europa.

“Here on Earth, the transport of heat and salt and nutrients in our oceans is critical to sustaining the biosphere—which is all the living things,” Miller said. “Ocean dynamics are a key for life on Earth. So in the search for life beyond Earth in astrobiology, understanding the fluid dynamics of how those ocean worlds like Europa work is a really interesting problem to look at.”

NASA also has its attention focused on Europa and is currently developing the Europa Clipper mission with a planned 2024 launch date. The stated goal of the mission is search for signs of habitability on Jupiter’s icy moon. The spacecraft for the Clipper mission will orbit Europa and use its cameras, spectrograph, spectrometer, magnetometer, plasma instrument, radar, surface dust analyzer, and other instruments to gather data to help answer questions about the potential for life to exist in Europa’s ocean.

The data produced by the mission will inform models and help planetary scientists paint a clearer picture of what is going on beneath the ice in Europa’s ocean. When that data starts to come in, Miller will most likely no longer be at Cornell. If the mission launches on schedule in October 2024, the Clipper will not reach its orbit just above the icy surface until April of 2030.

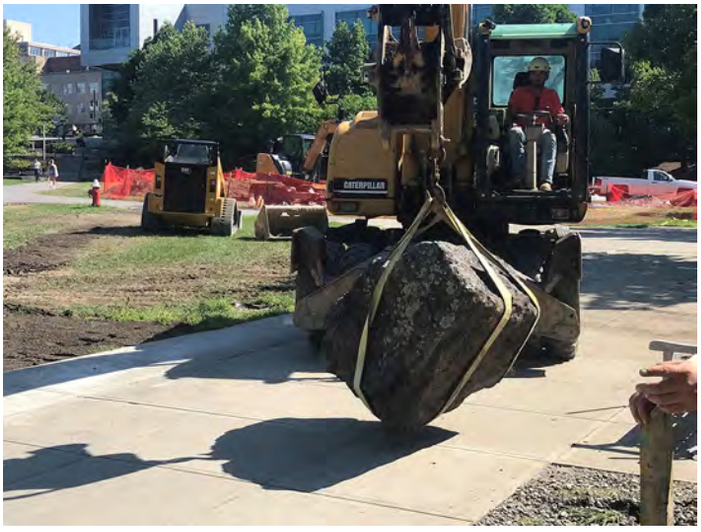
When Miller thinks about exactly what she’ll be doing as the Clipper swoops low over Europa and completes nearly 50 flybys, she can’t say with certainty. Her hope is that she will be working with NASA or another space agency as a project scientist---quite a goal for someone who did not know that “planetary scientist” was a career option just a few years ago.

Jupiter with Europa, one of its 80 moons. / Dreamstime.com

EAS NEWS

BENDER FAMILY ROCK GARDENS ON THE MOVE

If you've been on campus this fall, you may have noticed the Bender Family Rock Gardens have moved from their previous locations in front of Bard and Hollister halls, due to the Thurston Hall expansion, to a spot in front of Hollister Hall on the Pew Engineering Quad.



One of the rocks gets moved to its new location on the Pew Engineering Quad.

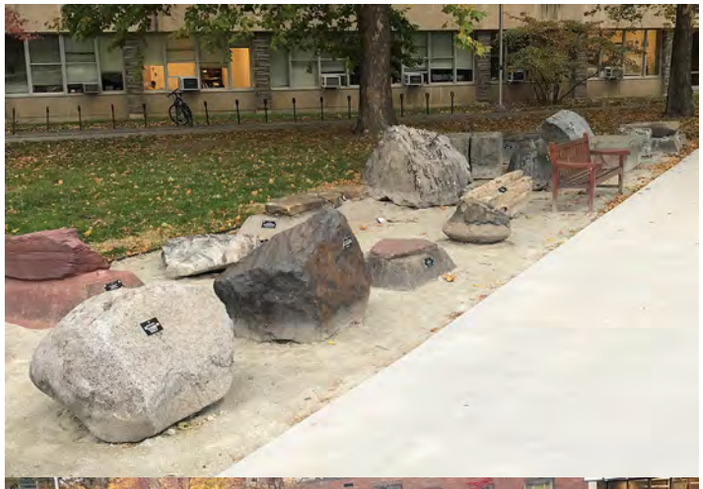
Professor and Chair of Earth and Atmospheric Sciences Geoff Abers said, "These two rock gardens were gifts of the Bender family. One represents a wonderful collection of rocks unique to New York state, the other is more widespread. These rocks are used by several faculty for teaching purposes. We are taking advantage of the move to reorganize the collection into a more pedagogically sound layout."

While there are now four rock parks in total, the first two were located on the Engineering Quadrangle: in the early 1970s, Rock Park East was installed in front of Kimball and Thurston Halls, the former home of the Department of Geological Sciences, and in the late 1970s, Rock Park West was situated in front of Thurston and Bard Halls. Gertrude and Meyer Bender '29 provided the funds to acquire the specimens and build the exhibits, the east park in honor of Mr. Bender's mother and the west park in honor of Mr. Bender's father.

When the Department of Geological Sciences moved into its new home in Snee Hall in 1984, the Benders again provided funds for a third park to beautify the entrance to that building, honoring Mrs. Bender's mother and father.

All the parks contain beautiful and unusual specimens that illustrate the diverse nature of our home planet.

EAS chair Geoff Abers consults with the construction foreman.

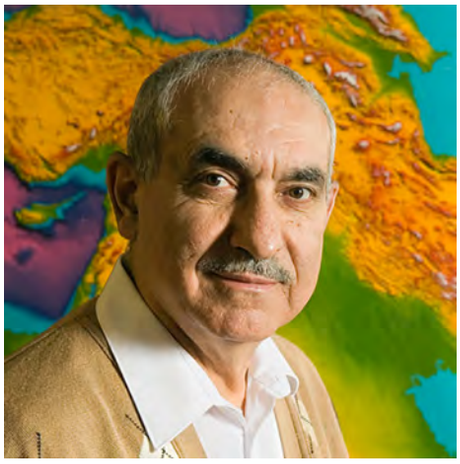


The Bender Family Rock Garden's new home, making it easier for passers-by to view all the specimens.

REMEMBERING MUAWIA BARAZANGI AT THE 2022 KAUFMAN INSTOC SYMPOSIUM

Former students, colleagues and friends gathered Friday, October 7 to celebrate the career and scientific accomplishments of Muawia Barazangi, who passed away March 30, 2022.

The Cornell University Institute for the Study of the Continents (INSTOC) hosted the 2022 Kaufman INSTOC Symposium at the Cornell Law School Auditorium, followed by a reception in Snee Hall Atrium.



Muawia Barazangi

Larry Brown Ph.D. '76, the Sidney Kaufman Professor in Geophysics in the Department of Earth and Atmospheric Sciences and a co-organizer of the symposium, welcomed those in attendance and shared his memories of Professor Barazangi. Guests sharing their stories included Nimat Barazangi Ph.D. '88; Klaus Jacob (Columbia University); Nobl Barazangi '94 spoke in person, followed by online attendees Driss Bensari (Morocco); Mustapha Meghraoui (Institut de Physique du Globe de Strasbourg, France); Abdelkrim (Karim) Aoudia (International Centre for Theoretical Physics, Italy); and John Coyne M.S. '88 (International Atomic Energy Agency, Austria), his wife Elissavet Pontikakis, and daughter Kassanthra Coyne.

Dr. Nobl Barazangi '94, Muawia Barazangi's daughter. / Steve Gallow

More in-person tributes followed from Yosef Al Shoffe (Freeville, NY); Eric Sandvol (University of Missouri); Graham Brew Ph.D. '01 (Dynamic Graphics); Alex Calvert Ph.D. '99 (Total); Michael Hamburger Ph.D. '82 (Indiana University); Eric Fielding Ph.D. '89 (Jet Propulsion Lab); Jack Caldwell Ph.D. '78 (Geospace Technologies); Paco Gomez Ph.D. '99 (University of Missouri); and Weldon Beauchamp Ph.D. '98 (New Mexico School for the Arts).

A final round of online attendees remembering Professor Barazangi included Lynn Sykes (Columbia University); Simon Klemperer Ph.D. '85 (Stanford University); Dogan Seber Ph.D. '95 (Nuclear Regulatory Commission); Whyjay Zheng Ph.D. '20 (University of California, Berkeley); Paul Morgan M.S. '20 (University of Washington); and Elianna Nossa Ph.D. '16 (George Mason University)..

(left to right) Nobl Barazangi, Rengin Gök, Eric Fielding, Paco Gomez, Alex Calvert, Nimat Barazangi, Weldon Beauchamp, Eric Sandvol, Graham Brew, Christine Sandvol. / Steve Gallow Photography.

Closing remarks were made by Professor and INSTOC Director Matt Pritchard, who encourages everyone to watch Muawia's talk about his career to the Snee Graduate Organization in 2018: https://www.youtube.com/watch?v=f7F8__RJeGs.

It's not too late to contribute to the Muawia Barazangi INSTOC fund: "In lieu of flowers, the family has asked for contributions to Cornell University's Institute for the Study of the Continents, which Muawia helped found and guided through much of his career. Contributions can be made via this link. Please indicate that this in honor or memory of Muawia Barazangi, and type "INSTOC" in the "other designations/special instructions" box." You can also send a check by mail, if you prefer, to Cornell EAS, 2160 Snee Hall, 112 Hollister Drive, Cornell University, Ithaca, NY 14853.

Plans are underway for the 2023 INSTOC Symposium on the Cornell Andes Project to honor the careers of Rick Allmendinger, Terry Jordan and Suzanne Kay. We hope that you are available to attend: the planned dates are Saturday/Sunday, June 3-4, 2023. More details will be available by the end of the year. Remote viewing of the presentations will be available.

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