2022

Impact

The Magazine of the College of Earth and Mineral Sciences

PennState
College of Earth and Mineral Sciences

Celebrating
125
YEARS
1896 – 2021

CONTENTS

Features

Sections

On the cover...

Urban market vendors and high-biodiversity produce in Peru.

Credit: Karl S. Zimmerer

All photos, unless noted, provided by Penn State.

This publication is available in alternative media on request.

Optimistic about the future

I'm sitting in the Florida Keys as I write this, finally able, with co-instructor Ray Najjar, to run our biannual marine biogeochemistry field trip, graciously funded by alumna Jan Kappmeyer and her husband, Drew Isaacs. COVID-19 isn't quite in the rearview mirror, but it feels like it down here: after all testing negative and spending much of our time outdoors, we're mask-free and enjoying discovering the secrets of nature together. We'll return to State College if the typical Spring Break snowstorm allows, and transition to the "new normal" having learned from the lessons of the past two years.

Learning from the past, both deep time and the more recent past, to better predict the future is one of the many things this college does particularly well. In this issue we learn how Kim Lau is decoding the rock record to learn about environmental conditions that led to the "Great Dying" some 250 million years ago, when most species on Earth went extinct. Climate change seems to have been a major driver of extinction back then, and as we learn from Ken Davis, climate change poses a significant threat to the planet today. In response, society is undertaking an energy transition from the fossil fuels that have powered the industrial era and the information age to the renewable energy sources of the future. That transition will require raw materials necessary for solar panels and wind turbines, as well as for semiconductors, cell phones, advanced medical instruments, and defense systems. As it has in the past, Penn State is collaborating with the Commonwealth to utilize its vast resources, in this case, rare earth elements, lithium, cobalt, manganese, aluminum, and other materials present as natural ores but also abundant in coal waste. Sarma Pisupati is leading the effort to bring together Penn State's research and manufacturing expertise to capitalize on this opportunity. Our materials science and engineering researchers, led by Joan Redwing, are inventing new ways in which extremely thin, two-dimensional materials will revolutionize electronics of the future. And Karl Zimmerer explains how growth of urban areas may be getting a bad rap in terms of its impact on food and land use.

All that our faculty, staff, and students are learning about the past and, together with our alumni and friends, doing to create a better future, fills me with optimism. I hope it does for you as well. Please consider us your lifelong partner in this journey.

Lee Kump, John Leone Dean

Impact

John Leone Dean
Lee Kump

Editor/Design
Patricia Craig

Writers
Matthew Carroll, Patricia Craig, Mike Dawson, David Kubarek, Francisco Tutella, A'ndrea Messer, Jamie Oberdick, Courtney Robinson, Angela Rogers

Email
EMSmagazine@psu.edu

Web
www.ems.psu.edu/college-magazine

Correspondence
Impact Magazine
510 Penn State Innovation Hub
123 S. Burrowes Street
State College, PA 16801

Follow Us

facebook.com/psuems
twitter.com/PSUEMS
instagram.com/psu_ems
www.youtube.com/c/PennStateCollegeofEarthandMineralSciences
www.linkedin.com/groups/6781082/
www.flickr.com/photos/psuems/albums


Pixabay

Researchers create integrated modeling of climate impacts on electricity demand and cost

Energy systems are increasingly impacted by the effects of a changing climate, especially the electric-power system, and are vulnerable to natural stressors such as wildfires, severe storms, extreme temperatures, and long-term disruptions of the hydrological cycle.

Impacts can cascade through energy systems, although models have yet to capture these compounding effects. A team of researchers led by Mort Webster, professor of energy engineering, developed a coupled water–power–economy model to capture these interactions in a study of the exceedance of water temperature thresholds for power generation.

"Our team developed a framework to investigate what we need to do for our systems to be ready for the next fifty to one hundred years of shocks and how to make them more resilient," said Webster. https://bit.ly/3w0k7EL

Penn State joins $72M NASA consortium to study Earth system science

Penn State is one of the higher education institutions and other organizations that are part of the new Goddard Earth Sciences Technology and Research (GESTAR II) consortium, which seeks to improve our understanding of the Earth system and our ability to observe, model, and predict its environmental changes.

A major emphasis of the $72 million consortium, funded by the NASA Goddard Space Flight Center, is training the next generation of undergraduate and graduate students and providing a pipeline for them to go on to jobs at NASA and elsewhere.

"We are delighted to be a partner in GESTAR II," said Jose D. Fuentes, professor of meteorology and John T. Ryan Jr. Faculty Fellow, and a co-principal investigator on the project. "We very much look forward to interacting with the other partnering institutions and NASA Goddard Space Flight Center through our research and academic training." https://bit.ly/3q3zKrl

Grant to reduce, eliminate toxicity of coal mine dust

Increases in lung diseases have been related to respirable coal mine dust. Penn State was awarded a grant from the National Institute for Occupational Safety and Health to research ways to reduce or eliminate the toxicity of respirable coal mine dust.

The team is researching the use of chemical additives to reduce or eliminate dust toxicity. The team, led by Barbara Arnold, professor of practice in mining engineering, is investigating coal mine respirable dust including ultrafine particles of coal, coal-related quartz, coal-related pyrite, and diesel particulate matter, individually and in blends. The goal is to provide insight into the chemicals required to reduce or eliminate dust toxicity for each different material, which could lead to possible additive combinations to be used for different coal components. https://bit.ly/3l3fOv2


CDC

NASA/JPL-Caltech

Newly discovered carbon may yield clues to ancient Mars

NASA's Curiosity rover landed on Mars in August 2012, and since then has roamed Gale Crater taking samples and sending the results back home for researchers to interpret. Analysis of carbon isotopes in sediment samples taken from half a dozen exposed locations, including an exposed cliff, leave researchers with three plausible explanations for the carbon's origin—cosmic dust, ultraviolet degradation of carbon dioxide, or ultraviolet degradation of biologically produced methane.

"All three possibilities point to an unusual carbon cycle unlike anything on Earth today, but we need more data to figure out which of these is the correct explanation," said Christopher House, professor of geosciences. "This research accomplished a long-standing goal for Mars exploration—to measure different carbon isotopes, one of the most important geology tools, from sediment on another habitable world—and did so by looking at nine years of exploration." https://bit.ly/35NYtJw

Study explores how climate change may affect rain in U.S. Corn Belt

Research led by Andrew Carleton, the E. Willard and Ruby S. Miller Professor of Geography, investigated what effect soil moisture has on convective precipitation in the Corn Belt under different atmospheric conditions, such as dry or humid. Results indicate that air humidity is more important than soil moisture in influencing whether it rains in the United States Corn Belt, an agricultural area in the Midwest, stretching from Indiana to Nebraska and responsible for more than 35 percent of the world's most important grain crop. For the Corn Belt, continued warming is likely to shift crop types northward and with a longer growing season, likely increasing climatic and market economic uncertainties going forward, Carleton said. https://bit.ly/3I5JlPl

USGS

Pixabay

Penn State awarded $3.4 million contract to target plastic waste

Penn State has been awarded a $3.4 million contract from the REMADE Institute, a public-private partnership established by the United States Department of Energy, to fund research targeting the inefficient methods currently used to process and upcycle mixed plastic waste.

Upcycling is a process of recycling where the resulting product is of a higher value than the original item that was discarded. The research team led by Hilal Ezgi Toraman, assistant professor of energy engineering and chemical engineering, is developing a flexible, two-stage chemical recycling process that decomposes multiple types of plastic and then converts them to valuable chemicals that can be used to create new products. https://bit.ly/3HYCtZr

Mineral dating reveals new clues about important tectonic process

Ancient rocks on the coast of Oman that were once driven deep down toward Earth's mantle may reveal new insights into subduction, an important tectonic process that fuels volcanoes and creates continents.

"The Samail Ophiolite on the Arabian Peninsula is one of the largest and best exposed examples on the surface of the Earth," said Joshua Garber, assistant research professor of geosciences. "It's one of the best studied, but there have been disagreements about how and when the subduction occurred."

The study, led by Penn State scientists, investigated the timing of the subduction using nearby rocks from the Saih Hatat formation in Oman, which was subducted under the Samail Ophiolite, according to the researchers.

"What our findings suggest is that this continental material was not subducted deep into the mantle a long time before the ophiolite formed as previously thought," Garber said. "Our data supports a nice sequence of events that happened in a tighter window and that makes more geological sense."
https://bit.ly/3l7zZb9

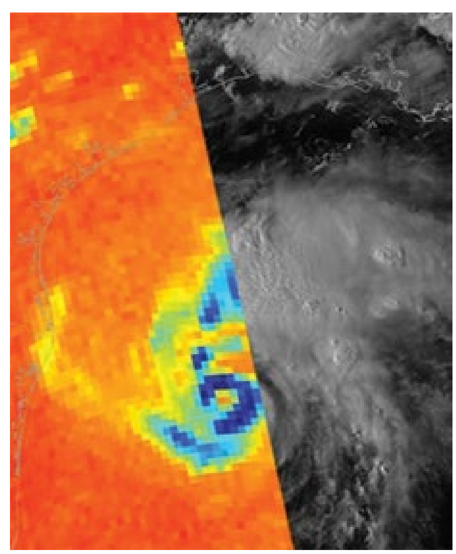
NASA

Lightning and subvisible discharges produce molecules that clean the atmosphere

Lightning bolts break apart nitrogen and oxygen molecules in the atmosphere and create reactive chemicals that affect greenhouse gases. A team of researchers led by William Brune, distinguished professor of meteorology, found that lightning bolts and, surprisingly, subvisible discharges that cannot be seen by cameras, or the naked eye, produce extreme amounts of the hydroxyl radical (OH) and hydroperoxyl radical.

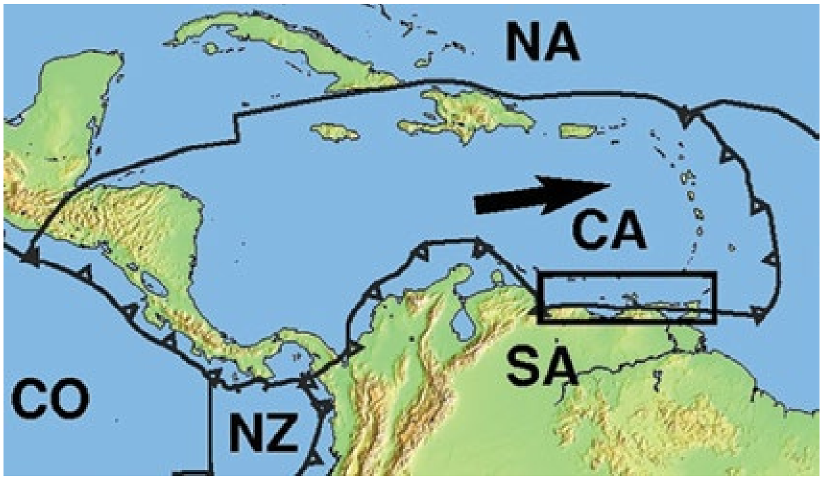
The hydroxyl radical is important in the atmosphere because it initiates chemical reactions and breaks down molecules like the greenhouse gas methane. The hydroxyl radical is the main driver of many compositional changes in the atmosphere. According to the researchers, "lightning-generated OH in all storms happening globally can be responsible for a highly uncertain but substantial 2 to 16 percent of global atmospheric OH oxidation."
https://bit.ly/3i9vli5

Microwave data assimilation improves forecasts of hurricane intensity, rainfall



A new technique using readily available data reduces forecast errors and could improve track, intensity, and rainfall forecasts for future storms like Hurricane Harvey. Adding microwave data collected by low-Earth-orbiting satellites to existing computer weather forecast models showed improvements in forecasting storm track, intensity, and rainfall when using Hurricane Harvey as a case study.

"Our study indicates that avenues exist for producing more accurate forecasts for tropical cyclones using available yet underutilized data," said Yunji Zhang, assistant research professor in meteorology and atmospheric science. "This could lead to better warnings and preparedness for tropical cyclone-associated hazards in the future."
https://bit.ly/3CEhVEf



Caribbean-South American plate boundary primed for major earthquake

Faults along the central portion of the Caribbean-South American tectonic plate boundary are primed to produce a powerful earthquake. An international team of scientists led by Penn State geoscientists combined GPS and Interferometric Synthetic Aperture Radar data to observe small changes to the ground along the boundary and used that to model where strain is building along the faults, indicating where the potential for earthquakes exists. The team found a significant portion of the Caribbean-South American plate boundary is locked and capable of producing up to a magnitude 8 earthquake.

"This is the first time this segment of the Caribbean–South American plate boundary has been investigated completely, and our results show where significant strain is accumulating and could help guide future seismic hazard decisions," said Peter La Femina, professor of geosciences. https://bit.ly/3CEWrYa

Paper on geovisual analytics wins 'Test of Time' award

A 2011 paper authored by Penn State researchers outlining a geovisual analytics approach to support geographically grounded situational awareness of crisis events using social media was selected to receive the 2021 IEEE Symposium on Visual Analytics Science and Technology Test of Time award. The award is an accolade given to recognize articles published at previous conferences in which the contents are still vibrant and useful today and have had a major impact and influence within and beyond the visualization community.

The research for the paper, "SensePlace2: GeoTwitter analytics support for situational awareness," was led by Alan MacEachren, professor emeritus of geography and information science and technology, who retired in June 2021. Anthony Robinson, associate professor of geography, was a co-author on the paper. https://bit.ly/3J6fdtP

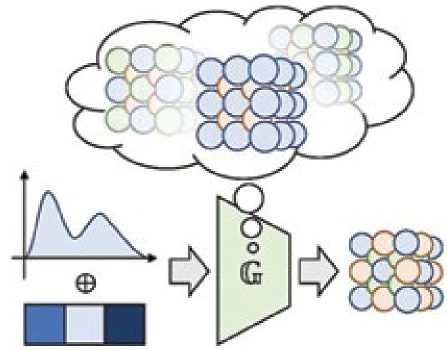
Fire operations-prescribed burning combo reduces wildfire severity up to 72 percent

Firefighters battling wildfires in the western United States use a variety of suppression tactics to get the flames under control. Research led by Alan Taylor, professor of geography and ecology, measured the effectiveness of suppression operations and previous prescribed fires on fire severity and found that prescribed burns, or controlled fires intentionally set to clear shrubs and forest litter before a wildfire ever ignites, can make fire suppression operations almost three times as effective in limiting wildfire severity.

"Prior to this study, no one looked at the combined effectiveness of fire suppression operations and prescribed fires and quantified how important this interaction is in terms of fire severity," said Taylor. "Those operations wouldn't have been as successful without the prescribed burns." https://bit.ly/3t42j9X


Cecilio Ricardo, USDA Forest Service

AI behind deepfakes may power materials design innovations



The person staring back from the computer screen may not actually exist, thanks to artificial intelligence (AI) capable of generating convincing but ultimately fake images of human faces. Now this same technology may power the next wave of innovations in materials design, according to Penn State scientists.

"We hear a lot about deepfakes in the news today—AI that can generate realistic images of human faces that don't correspond to real people," said Wesley Reinhart, assistant professor of materials science and engineering. "That's exactly the same technology we used in our research. We're basically just swapping out this example of images of human faces for elemental compositions of high-performance alloys."

They trained a generative adversarial network to create novel refractory high-entropy alloys, materials that can withstand ultra-high temperatures while maintaining their strength and that are used in technology from turbine blades to rockets.

"Our preliminary results show that generative models can learn complex relationships in order to generate novelty on demand," said Zi-Kui Liu, Dorothy Pate Enright Professor of Materials Science and Engineering at Penn State. https://bit.ly/35TFtsX

Cold sintering may open door to improved solid-state battery production

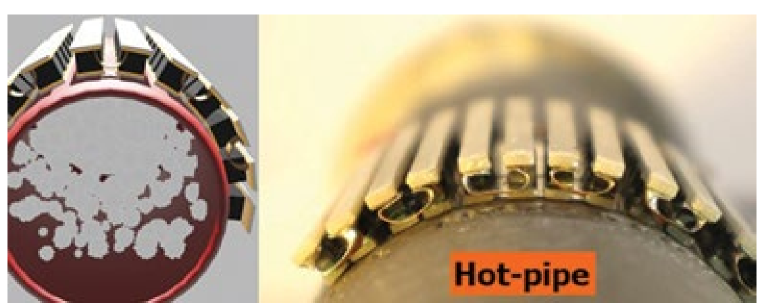
Compared to their traditional battery counterparts, solid-state batteries have higher energy potential and are safer, making them key to advancing electric vehicle development and use. One of the larger issues for solid-state batteries making the leap from laboratory to the market is the great challenges inherent in their production.

Cold sintering, developed by Penn State scientists, allows sintering of ceramics at a much lower temperature than traditional methods, therefore using much less energy and enabling potential new material combinations. Cold sintering enables introducing the sintered solid electrolyte at very low temperatures and may open up a whole window of co-processability between the solid-state battery materials that you can't get from any other ceramic processing method.
https://bit.ly/3q2gXwB

Form fit: Device wraps around hot surfaces, turns wasted heat to electricity

The energy systems that power our lives also produce wasted heat—like heat that radiates off hot water pipes in buildings and exhaust pipes on vehicles. Penn State researchers have been working to improve the performance of thermoelectric generators—devices that can convert differences in temperature to electricity. When the devices are placed near a heat source, electrons moving from the hot side to the cold side produce an electric current.

In prior work, the team created rigid devices but now have developed a new manufacturing process to produce flexible devices that offer higher power output and efficiency. Flexible devices better fit the most attractive waste heat sources, like pipes in industrial and residential buildings and on vehicles, and do not have to be glued on surfaces like traditional, rigid devices. https://bit.ly/3q0T5cK



Energy and sustainability policy student balances education, disaster response

Alex Swithers, a Penn State World Campus student majoring in energy and sustainability policy (ESP) while simultaneously working as a first responder for areas devastated by natural disasters and raising a young family, is frequently called out to storm-ravaged areas.

Swithers works for TRC Companies, which is a consulting, engineering, and construction company focused on a range of areas, including the energy, sustainability, government, and transportation sectors. Swithers works on a team that assesses storm damage and devises a plan to mitigate it.

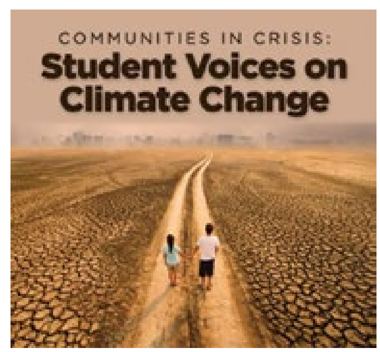
"We love seeing our students excelling in their fields, real-time," said Haley Sankey, assistant teaching professor in the John A. Dutton e-Education Institute, which administers the ESP program through Penn State World Campus. "Many of our students already work in industry where they're able to apply their classroom learning immediately." https://bit.ly/3i7bXCI

College offsets carbon emissions one tree at a time

In an effort to help the Chesapeake Bay Foundation's goal of planting ten million trees in Pennsylvania by the end of 2025, students spent a Saturday planting nearly five hundred shrubs and trees in Centre Hall, Pennsylvania. The trees were planted on property owned by research professor and EMS Sustainability Council head Tim White, who organized the event.

In addition to helping the Chesapeake Foundation reach its goal, White and his fellow organizers saw the event as an opportunity to help the college offset its carbon emissions. https://bit.ly/3neOseH

Interactive student project puts 'Communities in Crisis' on the map



Students in the course, Earth 103N – Earth in the Future: Predicting Climate Change and Its Impacts Over the Next Century, published a web book detailing communities in crisis due to climate change. The book includes more than one hundred student-created stories generated over the past few semesters and is available online at https://psu.pb.unizin.org/communitiesincrisis. Organized by Timothy Bralower, professor of geosciences, and April Millet, assistant teaching professor in the John A. Dutton e-Education Institute, the course addresses the impact of climate change on communities around the world. Book entries shed light on the threats forecast for the future and solutions based on student essays. https://bit.ly/3CXCj3w

Doctoral student returns home to study active volcano on La Palma

Judit Gonzalez-Santana, a doctoral student in geosciences studying volcanoes, first heard news that the volcano on La Palma Island in the Canary Islands was showing evidence of increased seismic activity about a week before it erupted in 2021.

Gonzalez-Santana, who hails from the Canary Islands, traveled home in November to work with the Canary Islands Volcanological Institute, known as INVOLCAN, to gather data by land and by boat. At times, she joined a crew to take gas measurements about 650 feet from the eruptive vents. Other times, she took ash samples or images of the volcano's cone using a thermal camera that could accurately capture the heat both day and night.

Much of this data, she said, can also be captured by remote sensing techniques such as satellites. But it's often "ground-truthed" with local measurements. For someone used to seeing the data from afar, she said the experience was eye-opening and educational.

https://bit.ly/3J6pWoR

First student graduates from spatial data science master's program

At Penn State's fall 2021 commencement exercises, Karen Dedinsky was the first student to receive a master's degree in spatial data science.

The program was created in 2020 to address the increasing demand for geospatial scientists who have the technical skills to leverage location data and create predictive models about spatial patterns. The first students enrolled for the spring 2021 semester. The program is offered online in partnership with the college and Penn State World Campus

In addition to her master's degree, Dedinsky graduated in 2020 with a bachelor's degree in meteorology and atmospheric science and minors in geographic information systems and geography.

https://bit.ly/3iWxTRb

Stellar showing at annual Graduate Research Exhibition

EMS students won six awards at the 2021 annual Graduate Exhibition, including first and second place in the both the engineering and physical sciences and mathematics category. In the engineering category, Amy Farley (geographic information systems) took first place and Prakash Purswani (energy and mineral engineering) earned second place. In the physical sciences and mathematics category, Sierra Melton took first place and Julia Carr took second place, both majoring in geosciences. Si Athena Chen, (geosciences) placed third in video option. Carr also received the Data Visualization Award offered by the University Libraries' Data Learning Center. https://bit.ly/3jTnrv6

Research, field experiences point geosciences student to energy-focused degree

When Cameron Brown was born, his mother—a labor and delivery nurse at a hospital in Queens, New York—introduced him to a tradition she gleaned from a Nigerian mother who was once her patient. As Brown took his first breaths, she whispered in his ear what she believed he would become—an architect. Flash forward two decades, and you'll find her prediction is on a path to being not too far off.

In 2022, Brown graduated from Penn State with a degree in geosciences after earning a degree in math from Fort Valley State University in 2020 through Penn State's 3+2 dual-degree partnership. The program is designed to open doors for underrepresented people in STEM fields and is putting Brown on a path to a doctoral degree—he's applying to UCLA—to, as he tells it, become "a geoscientist who is an architect for the green energy revolution."

Brown worked with a team of geoscientists and geochemists to track the path of shallowly injected wastewater from a coastal treatment plant. Using tools that track electrical resistance, the team can spot instances where wastewater mixes with the more electrically conductive saltwater. Because the research addresses groundwater, soil and rock permeability, and geochemical and geophysical methodologies, Brown said it fits perfectly with his career goals.

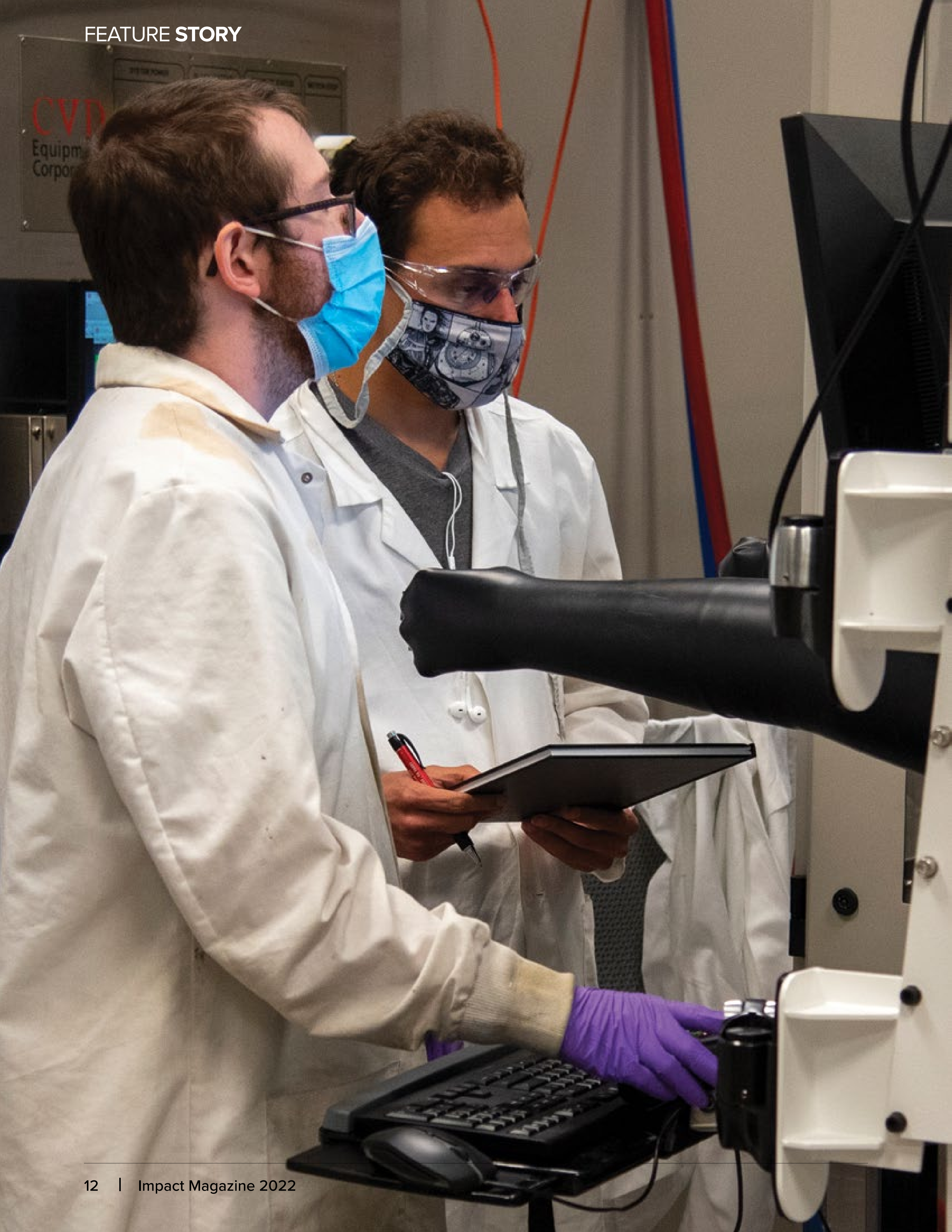
"My interests in geoscience are deeply rooted in resolving concerns related to the impact that energy production has on people and the environment. I believe that geothermal energy is one of the best solutions to this problem and requires the investment of more resources to be more accessible to people around the world. Conducting this research will significantly contribute towards this effort and prove useful in assisting environmental industries with the exploration of geothermal systems," Brown said. https://bit.ly/3L1UpUR

Symposium provides showcase for research, communication skills

Undergraduate students across Penn State's STEM fields joined research groups and conducted hands-on work, part of programs aimed at getting women, first-year students and other students from groups traditionally underrepresented in STEM their first exposure to research.

The programs—Women in Science and Engineering Research, Minority Undergraduate Research Experience and First-year Undergraduate Research Program (WISER/MURE/FURP)—held a symposium last fall where more than forty of those students gathered virtually to share their work with faculty, staff, and others outside their fields, through two-minute lightning talks.

Allison Beese, associate professor of materials science and engineering, developed the symposium and Erin DiMaggio, assistant research professor of geosciences, manages the WISER/MURE/FURP programs.
https://bit.ly/3ubJyAQ


CVD
Equipm
Corpor

BUILDING FOR THE FUTURE

Penn State facilities, expertise pave way for two-dimensional materials

by David Kubarek

As a materials scientist and director of the Two-Dimensional Crystal Consortium (2DCC), Joan Redwing often has to look far into the future to see the fruits of her labor.

Decades of research and the painstaking process of creating flawless materials—layer by layer—precede the application of the material in our everyday devices. But to see the team and the facilities required to get to that point, she doesn't have to look so far.

The 2DCC is a National Science Foundation (NSF)-funded Materials Innovation Platform national user facility, which is designed to pave the way for the implementation of next-generation materials while simultaneously training experts to work in the same realm. The facility, which was launched five years ago and recently received $20.1 million in continued funding from the NSF, is one in a few globally with such capabilities. In terms of its facilities, expertise and results, Redwing said, it's alone at the top.

"We've established the 2DCC as the premier facility in the United States for the synthesis of 2-D materials," said Redwing, whose disciplines merge materials, chemical, and electrical engineering. "There's really nothing similar to our facility in the United States and maybe the world. We're definitely recognized as leaders in the synthesis of these materials."

"We've established the 2DCC as the premier facility in the United States for the synthesis of 2-D materials."

~Joan Redwing

(Left) Doctoral candidate Nick Trainor, left, looks at a structure of a wafer-thin 2-D material created using chemical vapor deposition with a visiting student. That's a process very common in manufacturing yet can be used to create novel 2-D materials.

What are 2-D materials?

The materials we think of—a piece of plastic, the head of a hammer, a soda can—are so-called bulk materials because the material has three dimensions. For 2-D materials, which consist of a single layer of crystals, the material is a single layer of film.

What's unique about 2-D materials is that its properties often change dramatically. For example, silver is one of the most conductive materials in bulk form, where the electric current can flow in one or more directions. But as a 2-D film, it's a semiconductor, where the electric current has connectivity between a conductor and an insulator, allowing control of the current. It's capable of turning electric impulses on and off just like the silicon chips found in everything from your automobile to your cell phone.

We've known about the powerful properties of materials that in 2-D form have a strong bond in just two directions—think of a single sheet of paper laid flat—but creating perfect layers of these materials, until recently, has proved difficult, Redwing said.

2DCC's role is simplifying that process while using materials creation methods that are already prevalent in American tech industries and can easily be scaled up. Boosting American manufacturing and lessening the nation's global reliance on high-tech materials is one of the goals outlined by the NSF.

The role of 2DCC

From materials theory and computation—where supercomputers are used to help understand the properties of a material before it's even created—to synthesis, or creation, to the characterization, 2DCC has experts.

Synthesis is one area that stands out. While many facilities are able to create flakes of 2-D materials, Penn State is creating large-scale wafers similar to what's used commercially via a process known as chemical vapor deposition. In high-end electronics manufacturing, these wafers serve as the medium for which tiny slices of a material are harvested. The creation of these materials is also driving research at Penn State and beyond. The facility spends about half its resources creating films and crystals for researchers globally.

Because few electronics are made with one material, the next step will be creating complex layers of 2-D materials destined for new and hyperfast electronics. This could have a huge impact in areas of supercomputing, quantum computing, and high-tech electronics. And, because items like modern-day cars are employing the same technologies as a smartphone, these materials are becoming more commonplace.

The pace of discovery

The fevered pace of discovery is something that excites Joshua Robinson, a 2-D materials expert and director of user programs at 2DCC. Robinson said the globalization of knowledge has hastened the pace of research, and with that comes discovery.

He said the pace of published research is a double-edged sword: So much valuable research brings both knowledge and noise. That's why having a collaborative group within 2DCC reaps rewards.

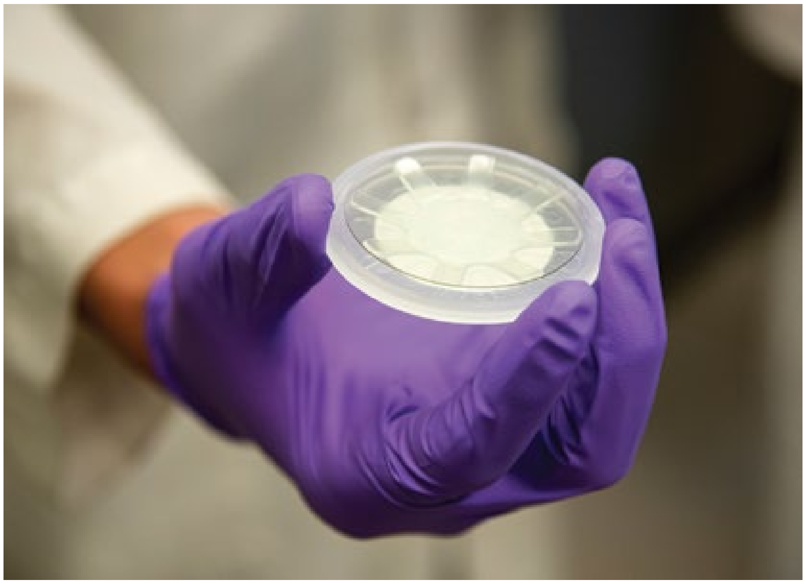
"Globalization of knowledge has hastened the pace of research, and with that comes discovery."

~Joshua Robinson

"There is this beacon at the NSF that people migrate towards. As opposed to all of us individually publishing papers, now we're doing it collectively as a team," Robinson said. "And that elevates the impact of our work, especially with the NSF recognition that Penn State is a special place that has unparalleled material science and research capabilities."

Robinson's group pioneered a method for creating graphene—that's the 2-D form of graphite—that can be used in anything from protecting metals from quickly oxidizing in demanding applications to extending the life of your car tires by reducing heat caused by road friction.

Robinson said the facility simultaneously advances research while advancing researchers. One program, the Resident Visitor Scholar Program,



The 2DCC at Penn State creates wafer-size materials that are the base for which tiny slices of a material are harvested for use in high-end electronics manufacturing.

invites graduate students and early-career researchers to train at the facility.

"This really is about expanding our knowledge of two-dimensional crystals while advancing the education of next-generation scientists," Robinson said.

A generation to lead the way

When 2DCC leaders talk about training the next generation of experts, they mean people like Nick Trainor, who came to Penn State in 2019 to earn his Ph.D. in materials science and engineering. Trainor earned the NSF Graduate Research Fellowship in 2020.

Trainor said the facilities, faculty, and training-centric approach drew him to the University. He's not certain if he'll enter academia or the private sector after graduating but he knows his skills in both research and training—he helps shadow visiting graduate students at the 2DCC facility—will help him earn a career in either.

As an undergraduate at Drexel University, Trainor worked in 2-D materials. For his doctoral thesis at Penn State, he's investigating heterostructures. These structures, which combine several 2-D materials to achieve more complex functions, will be the next big breakthrough in the realm because most electronic devices require it.

Trainor sees these heterostructures as not some big pipe dream for researchers but rather something attainable in his career. In fact, that's one reason he chose to work in 2DCC. The techniques are already prevalent.

"Chemical vapor deposition is a process where we feed compounds into a reactor as gases and those compounds react and then deposit as a film," Trainor said. "This technique is actually very common. It's used in making LEDs and lasers. What we're doing here in principle can readily be transferred out to real world manufacturing."

As the future of manufacturing plays out, Redwing hopes to continue to guide Penn State on a path that's leading the way in the creation of all forms of materials, not just 2-D materials. Doing that, she said, will require more faculty, funding, and facilities.

"I would like to see Penn State become the premier institution in the United States for material synthesis overall," Redwing said. "I'm hoping a lot of the equipment that we've put in place for 2-D materials can also help to grow Penn State's strength in semiconductors and related electronic materials. My ultimate goal is to further build our strengths in material synthesis." ⌘

NSF renews funding for 2DCC

The 2DCC, one of two inaugural Materials Innovation Platforms or MIPs, received its initial funding in 2016 from the National Science Foundation. It underwent a renewal process for a second five years of funding in 2020 and in May 2021 was awarded $20.1 million over five years, an increase of 13 percent above the initial award in 2016.

The 2DCC, led by Joan Redwing, follows the "materials by design" concept, combining synthesis, characterization and theory/simulation applied to targeted outcomes to accelerate materials discovery. Its first five years of funding was used to nucleate and grow the MIP by developing state-of-the-art equipment for thin film deposition with integrated characterization tools, establishing a bulk growth facility, developing new computational tools, and a facility-wide database, and initiating an external user program.

Joan Redwing, distinguished professor of materials science and engineering

"As an inaugural Materials Innovation Platform, 2DCC MIP exemplifies the power of the Materials Genome Initiative approach with close experiment-theory interactions," said Charles Ying, program director for MIPs and National Facilities and Instrumentation with NSF's Division of Materials Research. "Multi-year efforts of studying and refining growth conditions have paid off, leading to reproducible synthesis of 2-D materials that have already benefited more than one hundred scientists nationwide. The new experimental and data tools will bring 2DCC to a new level in its second five years."

https://bit.ly/36bZ1ZU

Strengthening food biodiversity among the urban poor can improve the situation of food and nutrition insecure populations. Retailing fresh vegetables, like the multi-color carrots and radishes shown in this photo taken at an urban farmers' market, and other local foods is a key function, as is raising nutrition and food-system awareness.

Karl S. Zimmerer

URBANIZATION AS A FORCE FOR FOOD DIVERSITY AND LAND USE SUSTAINABILITY

Urbanization-agrobiodiversity nexus is crucial to strengthen food-system sustainability and sustainable development

by A'ndrea Messer

Widely accepted myths that urbanization negatively impacts food and land use biodiversity are incorrect, according to a team of researchers who developed a framework for evaluating this intersection. Their results could affect nutrition and food insecurity in urban areas.

More than 50 percent of humanity currently lives in urban areas and by 2050 this will grow to 68 percent. Growing urbanization drives changes in climate, land use, biodiversity, and the human diet, as described by this research team.

"We can't simply assume that urbanization exclusively, negatively impacts food biodiversity," said Karl Zimmerer, E. Willard and Ruby S. Miller Professor of Environment and Society Geography, who directs the GeoSyntheSES Lab.

The framework, which was published in the journal ***One Earth,*** looks at the intersection of urbanization and agrobiodiversity—biodiversity in food production and consumption as well as agricultural ecosystems—in four different areas: land use; supply chains; food access and foodways; and urban infrastructure and food retail.

Approaches to link urbanization to biodiversity

Looking at urban and peri-urban land use, there are a wide variety of approaches that help food and nutritional biodiversity. On a city's fringe, crop land, orchards, and dairy farms can supply a range of products.

According to the researchers some U.S. metropolitan areas could become locally self-sufficient in eggs and milk, but only 12 percent and 16 percent in fruits and vegetables, respectively. However, in Hanoi, Vietnam, urban and peri-urban agriculture provides 62 percent to 83 percent of vegetables and significant levels of pork and fish.

Within a city, and peri-urban area gardens and farms of all sizes, whether they are public or private, roof top or pocket, add to the diversity of food available to residents.

"Most urbanization in coming decades will be based in Africa," said Zimmerer. "Asian cities have already grown, but increases will be much higher in Africa. The interesting thing is Africa will have increasingly large, peri-urban, and urban spaces with small farms and gardens. Nutrition and food security will be paramount."

Importance of supply chains

Because not all food in a city can come from the city or its surroundings, supply chains are very important. These supply chains are local, national, and international.

"Food security in U.S. is higher when we have supply chains that are more geographically diverse," said Zimmerer.

Zimmerer explained that currently, supply chains are very proprietary, and it is hard to get data because companies do not let information out, but that newly available datasets on commodity networks could be used in research.

According to the researchers, "national supply chains have been shown to drive increasingly standardized and biologically simplified crop and livestock raising, as well as to support pockets of diversified farming." So, supply chains can be both

Karl Zimmerer researches supply chain diversity of agrobiodiverse dry legumes in a South Asian food market in the New York metropolitan area.

good and bad depending on what they carry from where and the diversity of the products they carry. While less biodiverse food chains will still supply food to urban populations, they may not solve the problems of nutritional insecurity.

Influence of economics and culture

The third segment of the framework is influenced by economics and culture. Food access is extremely important and reports of food deserts in U.S. cities have spurred some actions. But according to Zimmerer, since the Green Revolution in the 1950s and 1960s—a push toward modern, mechanized agriculture in the developing world that focused on a few specific staple commodity crops—poor populations have been pushed to consume a less diverse but cheaper diet in which traditional foods and agricultural practices were deemed outdated.

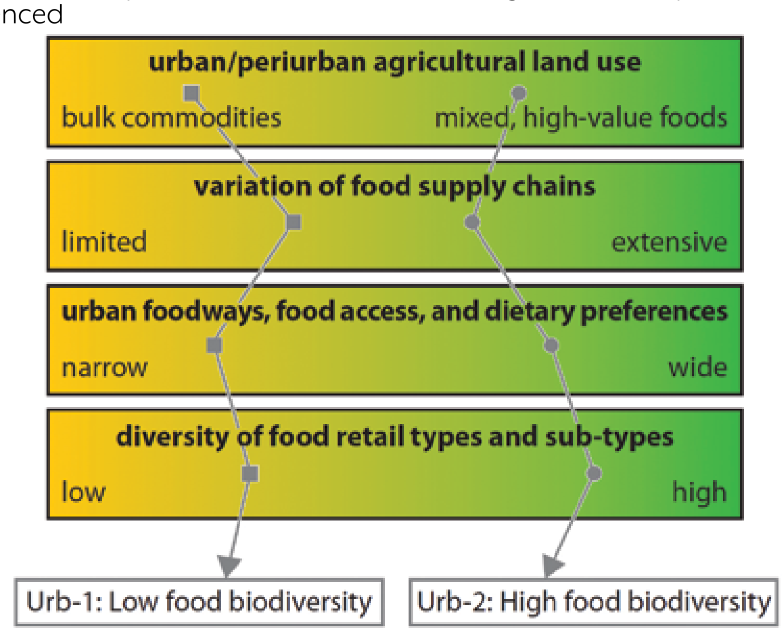
However, urban poor are often of varied cultural identities and carry with them the foodways of their respective cultures that Zimmerer and his colleagues address. These cultures and the foods they eat can diversify the foods available for all in the area. Access to a diversity of culturally varied foods can also increase nutritional security.

Urban infrastructure and food retail

The final branch of the framework is urban infrastructure and food retail, which show both challenges and opportunities for accessible, healthy food. Retail possibilities in an urban context include supermarkets, grocers, convenience or corner stores, formal and informal urban open-air markets and food delivery, street vendors, restaurants, and other eateries.

This variety of options supplies a fertile field for investigating how urban infrastructure and retail outlets provide access to urban residents. Some of these possibilities include using data collected from bar codes or restaurant websites to track the food biodiversity within a city or urban area.

The researchers detailed how using this framework and the interconnectedness of the urban peri-urban environment with agrobiodiversity will



Framework of urbanization-agrobiodiversity linkages and pathways.

help debunk the myth of these two vital conditions as incompatible.

They noted that the processes of urbanization can have an intermediate period when agrobiodiversity is low, especially among the urban poor.

Reduced food biodiversity is marked by simplified diets that reflect low-agrobiodiversity and cheap-food commoditization. Strengthening food biodiversity among the urban poor can improve the situation of food- and nutrition insecure populations, as guided by this research.

"We conclude the urbanization-agrobiodiversity nexus is a crucial new focus of interdisciplinary research to strengthen sustainable development and food systems," the researchers said. ⌘

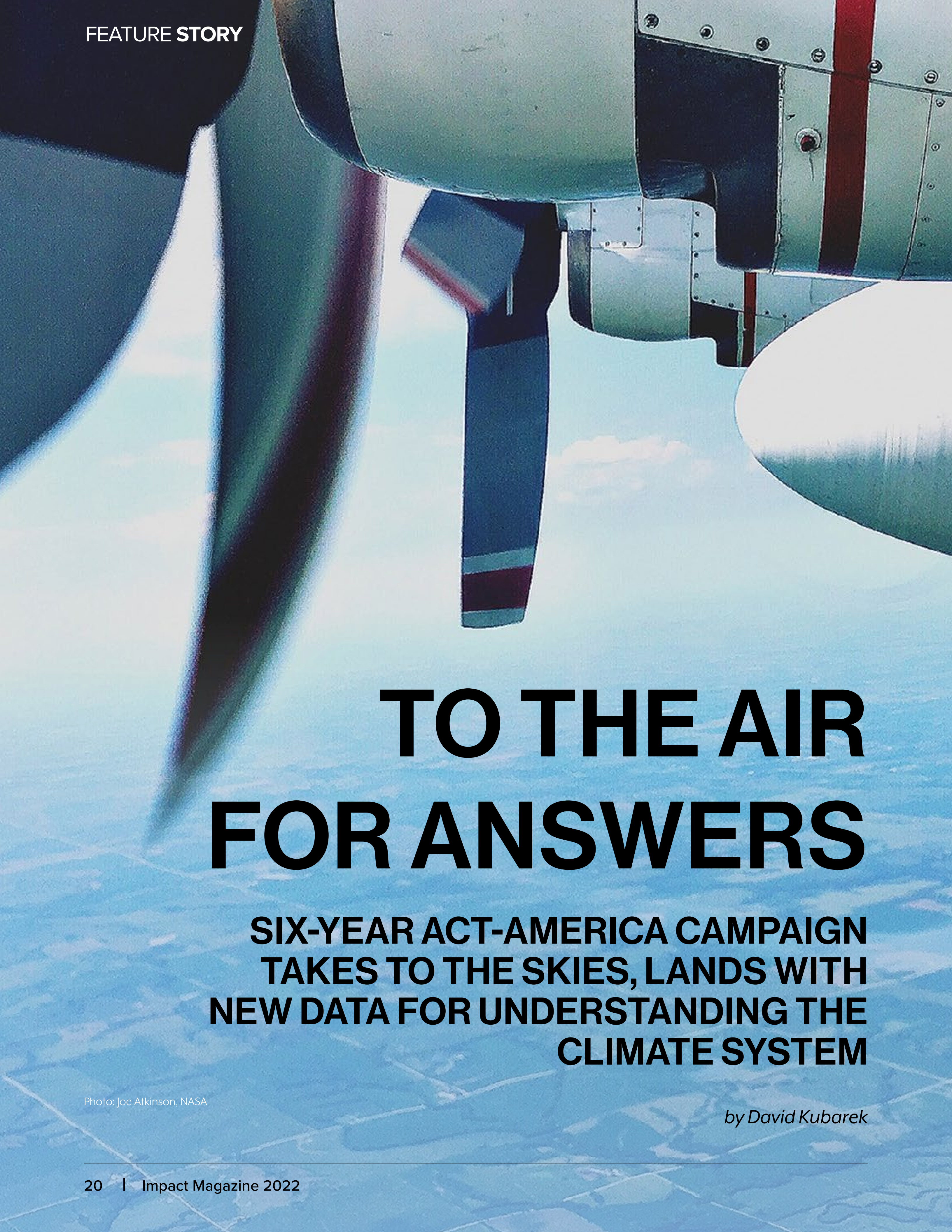
"The urbanization-agrobiodiversity nexus is a crucial new focus of interdisciplinary research to strengthen sustainable development and food systems."
~Karl Zimmerer

Karl Zimmerer

Agrobiodiversity can be common at the levels of multiple food species as well as varieties in urban and peri-urban farming and gardening. This peri-urban farm in Hanoi, Vietnam, relies on multiple vegetable species with agroecological techniques using low chemical inputs to provide safe, high-quality food. Multi-species farming enables year-round production.

Other reseachers on this project include Edward C. Jaenicke, professor of agricultural economics, Penn State; Chris S. Duvall, professor and chair of geography and environmental studies, University of New Mexico; Leia M. Minaker, assistant professor, Department of Planning, University of Waterloo, Ontario, Canada; Thomas Reardon, University Distinguished Professor of Agricultural, Food and Resources, Michigan State University; and Karen C. Seto, Frederick C. Hixon Professor of Geography and Urbanization Science, Yale University.

The National Socio-Environmental Synthesis Center, funded by the National Science Foundation, supported this work.



TO THE AIR FOR ANSWERS

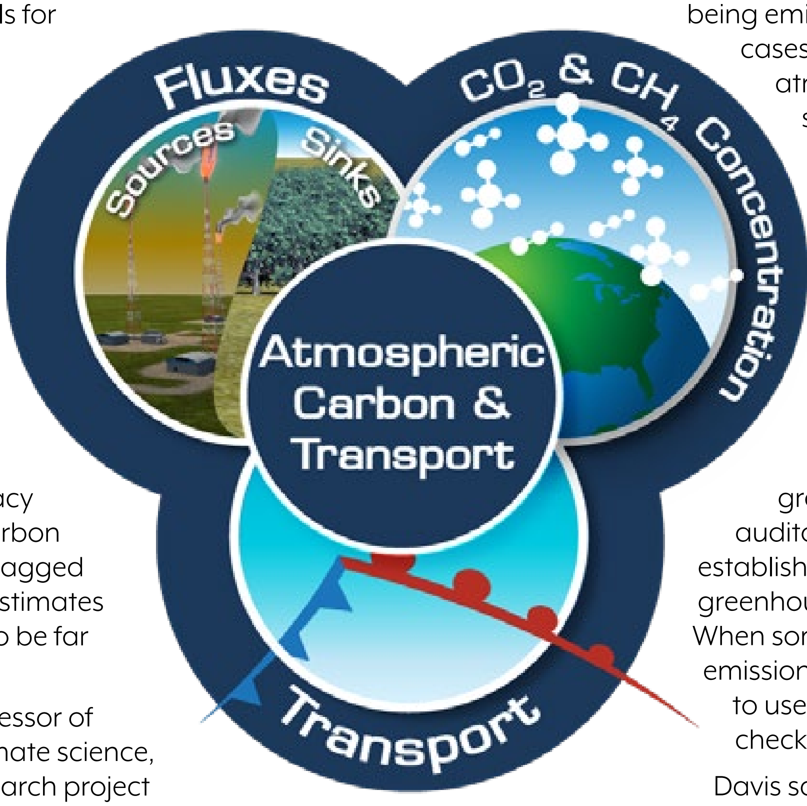
SIX-YEAR ACT-AMERICA CAMPAIGN TAKES TO THE SKIES, LANDS WITH NEW DATA FOR UNDERSTANDING THE CLIMATE SYSTEM

Photo: Joe Atkinson, NASA

by David Kubarek

As researchers tick off the list of accomplishments culminating from the past six years of the $30 million Atmospheric Carbon and Transport–America (ACT-America) research endeavor, they see the results not as soundbites or Hollywood-infused eureka moments in science, but as a carefully orchestrated campaign of more than one hundred experts working for years towards common goals to solve complex problems.

Some of their discoveries will long impact how we aid the management of greenhouse gases by improving our tools for auditing greenhouse gas sources and sinks: Researchers wrote the book on how greenhouse gases are moved by weather systems, laid the groundwork for advancing regional diagnoses of greenhouse gas sources and sinks, confirmed the accuracy of NASA's Orbiting Carbon Observatory-2, and flagged methane emissions estimates in the United States to be far too low.



For Ken Davis, professor of atmospheric and climate science, the decade-long research project began with a quest to understand what role weather plays in moving greenhouse gases through the atmosphere. To a researcher, it's an unanswered question but one that has global implications.

As global leaders recently met at the United Nations Climate Change Conference, much of the focus was on curbing greenhouse gas emissions and finding fair and equitable ways of measuring those emissions by nation.

Fields of green are an ever-present sight on the Aug.4, 2016 science flight, which nips down into Missouri before heading back up through Nebraska and into southern South Dakota, to measure carbon dioxide and methane around both sides of the front in NASA's C-130 Hercules research aircraft.

But little is known about the role weather plays in distributing these emissions. Understanding that, Davis said, will strengthen our existing methods for measuring greenhouse gas emissions. Atmospheric data captured in the ACT-America campaign could one day be used to better estimate greenhouse gas sources and sinks, leading to better monitoring and management of regional and global greenhouse gas emissions.

"We know with great accuracy the global trends in greenhouse gases, but we often don't know exactly where or how much these gases are being emitted into, or in some cases, removed from the atmosphere," Davis said. "Because of this uncertainty, there's a lot of interest in using atmospheric concentration measurements to find out precisely where these greenhouse gases are originating. Think of us as the greenhouse gas auditors. We're helping to establish the role of regional greenhouse gas auditors. When someone reports emissions, we want to be able to use the atmosphere to check their figures."

Davis said this improved auditing will also be used to improve existing models of greenhouse gas emissions and sinks. These models are needed to predict future climate scenarios.

ACT-America is born

NASA accepted Davis' proposal on his second try, said Mike Obland, mission manager at NASA's Earth System Science Pathfinder Program Office and former project manager for ACT-America. Obland suspects some of the measurement technology wasn't quite ripe the first time around.

Obland worked with Davis to pull off one of five Earth Venture Suborbital-2 missions—the biggest non-space-based project of his career—which resulted in three years of domestic flights merged with a growing portfolio of research results. The first year of the project was spent instrumenting the two research aircraft—a Lockheed C-130 Hercules and Beechcraft Air King B200 —and the final eighteen months were entirely devoted to research using the data collected by the flights.

The team logged over 1,100 flight hours with takeoffs from three points in the United States, often using the planes in coordinated flight patterns at multiple altitudes sampling weather systems or flying directly underneath space-based satellites. Researchers said it was important to gather flight data from different seasons and years to capture a general understanding of conditions over the central and eastern United States. The resulting data, the first airborne record of how greenhouse gases are distributed within weather systems is in the public domain as per NASA's public mission, and is propelling research within the campaign and beyond.

What the skies tell us

One key finding, Davis said, is that we have a better understanding of how greenhouse gases—particularly methane—pool within and are transported by weather systems.

This comes into play heavily as nations grapple with solutions for climate change. They need to know the sources and the sinks—processes where greenhouse gases are emitted into or remove from the atmosphere.

"With this campaign, we've begun to improve our tools for auditing greenhouse gas sources and sinks as nations try to manage climate change. If we can't measure the sources and sinks well then we're flying blind. We don't know the impact we're having. These atmospheric measurements have a lot of promise for helping us identify and quantify these sources and sinks."

~Ken Davis

This plays out in another key finding of the mission: the true impact of the oil and natural gas industry on climate change. Using ethane as a tracer, researchers, for the first time in a multi-season, continental-scale atmospheric campaign, revealed the sources of the methane seeping into the skies. Methane, which is produced from oil and gas wells and also biologically in cows and other processes such as rice paddies, wetlands, coal mines, and landfills, is more than eighty times as potent over twenty years as the greenhouse gas carbon dioxide but has a life in the atmosphere of about ten years, far less than the hundreds of years for carbon dioxide. Ethane isn't present in livestock produced methane.

Davis' team found that emissions of methane from oil and natural

David C. Bowman, NASA

Bianca Baier, then a postdoctoral researcher and now a research scientist at NOAA, and Ken Davis, ACT-America principal investigator, talk during a flight. Baier received her B.S. in mathematics, her M.S. in atmospheric chemistry, and her Ph.D. in atmospheric chemistry, all from Penn State.

Davis took this photo over the midwest during a flight to validate remote sensing data from the Orbiting Carbon Observatory-2 (OCO-2) satellite. OCO-2 uses near infrared reflection to make its measurements of carbon dioxide. Snow is dark in the near infrared, though, meaning it's not reflective, so satellite validation flights like this one can help researchers see how well OCO-2 is working as it collects measurements while orbiting over snow-covered land.

gas wells were at least 60 percent greater than those estimated by the EPA's method for emissions accounting.

This discrepancy, said Zach Barkley, assistant research professor, points to problems with the EPA's inventory approach. The inventory is an accounting method based on data like well counts, gas production, and typical leak rates for the equipment used in the gas and oil production fields. However, Barkley said, the method is simply missing a lot of gas.

"There are systematic problems in the way the EPA calculates these emissions and natural gas has just always been a larger source than we expected," Barkley said. "The next task, obviously, is to figure out where these emissions are coming from and find the most efficient way to reduce them."

Efforts to use satellites such as the Orbiting Carbon Observatory are coming into the fold. The good news, said Davis, is that their team found the methods—which estimate the carbon dioxide levels using sunlight that's reflected from Earth—to be very accurate. There was no discernible difference between the spatial gradients in aircraft-based and satellite-based carbon dioxide measurements when the skies were clear.

That's great news, said Davis. However, warm and cold fronts within weather systems are known for two things: clouds and transport of greenhouse gases, and currently satellite instruments can't measure greenhouse gases through clouds. So, work remains.

Science of weather systems

Improving how fronts and storms are represented in models allows us to improve our models of atmospheric greenhouse gas transport, said Tobias Gerken, assistant professor at James Madison

David C. Bowman, NASA

The ACT-America team with the two specially designed planes, a B200 King Air (upper left) and C-130 Hercules (upper right), designed to investigate how weather impacts the flow of greenhouse gases across large portions of the United States.

University who worked on ACT-America while at Penn State, because it lets us connect the dots between regional and global measurements.

Currently, we grab greenhouse gas measurements from data points and rely on inversion models to paint the regional snapshots that collectively add up to the global carbon footprint.

"In order to understand how good these inversion models are, we need to understand how greenhouse gases flow through the atmosphere," Gerken said. "ACT-America was a really interesting project to work on because it reveals what's happening on a regional scale. It's the bridge between local and global data."

Investing in answers

"We are crucially dependent on understanding greenhouse gas processes going into the future," Gerken said. "So, we need the best possible tools available. That's an investment for NASA and the American taxpayer. Because of all the graduate students who worked on this project, it's also an investment in training the next generation of scientists at this critical time for climate change."

Davis said the research fills in some of the unknowns as we seek answers to auditing and managing climate change.

"With this campaign, we've begun to improve our tools for auditing greenhouse gas sources and sinks as nations try to manage climate change," Davis said. "If we can't measure the sources and sinks well then we're flying blind. We don't know the impact we're having. These atmospheric measurements have a lot of promise for helping us identify and quantify these sources and sinks." ⌘

FROM COAL TO CRITICAL MINERALS

ONCE DISCARDED AS WASTE, MINING BYPRODUCTS FROM APPALACHIA MAY PLAY ROLE IN GREEN ENERGY FUTURE

by Matthew Carroll

Once, coal was king in Pennsylvania. Black rock from Northern Appalachia heated buildings, powered trains, and fueled the growth of a nation.

As other fossil fuels—oil and natural gas—came for coal's crown, the industry faded. Jobs disappeared and environmental scars remained. Decades later, on the cusp of an apparent green energy revolution, the nation is again turning to its coal region.

In a twist of fate, coal and its byproducts represent a source of critical minerals like rare earth elements (REE), a group of seventeen minerals that are building blocks in a wide array of modern technology, including in electric vehicles, wind turbines, and other parts of a green economy.

REEs may not have household names—names like scandium, yttrium, gadolinium—but their importance in batteries, display screens, alloys, and powerful magnets has made them a backbone of modern electronics and essential for health care and military applications.

"Rare earths aren't exactly rare," said Barbara Arnold, professor of practice in mining engineering. "They're found everywhere. But they're rarely found in high concentrations, so mining for them often isn't economically viable."

Even as demand for products like hybrid cars and solar panels rises, the United States finds itself with a shortfall of critical minerals. The country currently imports nearly its entire supply due to the high financial and environmental costs of harvesting the materials.

"If we are moving toward renewable energy, buying cars with rechargeable batteries, we need to know where the materials are going to come from," Arnold said. "It's been stated that we can't recycle enough to meet this challenge, so we need to mine more."

A byproduct of coal mining, acid mine drainage sludge sites like ones in Central Pennsylvania (above photos) are rich in critical minerals that could contribute to creating a domestic supply of these materials.

The answers may lie in buried in landfills and acid mine drainage retention ponds in the coal region. These mining waste streams feature elevated concentrations of REEs and other critical minerals like aluminum and cobalt. And Penn State scientists are leading the charge to try and unlock these materials to help industry develop domestic supply chains.

"The Appalachian region has a rich history in mining, and because of this we have a lot of resources often left behind as waste streams," said Sarma Pisupati, professor of energy and mineral engineering "We at Penn State can help industry produce valuable materials while also remediating some of the environmental problems caused by these waste streams."

Penn State researchers, through the Center for Critical Minerals, have innovated new methods to extract REEs in higher concentrations. And the scientists are leading a new consortium of academia and industry, aimed at taking stock of the REEs resources available in the northern Appalachian region. The consortium is part of a broader national effort funded by the U.S. Department of Energy (DOE) to produce domestic supplies of critical minerals.

"The very same fossil fuel communities that have powered our nation for decades can be at the forefront of the clean energy economy by producing the critical minerals needed to build electric vehicles, wind turbines, and so much more," Secretary of Energy Jennifer M. Granholm said when the funding was announced. "By building clean energy products here at home, we're securing the supply chain for the innovative solutions needed to reach net-zero carbon emissions by 2050—all while creating good-paying jobs in all parts of America."

No stone unturned

Machines rumble and thump in the laboratory. Inside, rocks are crushed and then collected and smashed again into ever smaller pieces. A powder is fed through a water table that shakes and separates the material by weight, down to the finest grains. Taking some of the slurry in a pan, Arnold sees familiar golden flecks emerge.

She and her team are panning for gold in Hosler Building. More accurately, pyrite, or fool's gold, sparkles back at her. The yellow mineral, commonly found in coal, is a dead giveaway that these samples are leftovers from coal mining—rocks and clays found in the seam and discarded as waste because of their low value. But Arnold knows something worth much more could be hiding in her pan.

Now its Arnold's job to find potential sources of these materials in mining waste.

Arnold, managing director of the Consortium to Assess Northern Appalachian Resource Yield (CANARY) of Carbon Ore, Rare Earth Elements, and Critical Minerals (CORE-CM), is leading the search for these products in waste streams in northern Appalachia—from Kentucky through New York. The two-year, $1.2 million project, funded by the DOE, is part of a broader, nationwide effort to jumpstart domestic production of advanced carbon products and critical minerals.

Arnold and her rock crusher have been busy. She's spent parts of the past year testing samples collected in the field and sent to her by industry collaborators.

"These first two years are a fact-finding mission," she said. "We want to know where these waste streams exist, what's the best way to get them out and process them. All of the information we find is going into our database. We are really digging into the history of mining—not just coal mining—in Pennsylvania and beyond."

Penn State and its collaborators are tasked with assessing and cataloging northern Appalachian-basin critical mineral resources and waste streams; developing strategies to recover the materials from these streams; and identifying potential supply chain or technology gaps that will need to be addressed.

"The central goal is to develop the science and technology to fill any gaps and help industry take off as quickly as possible," said Pisupati, principal investigator of the project, director of CANARY and of the Center for Critical Minerals. "The idea is to catalyze economic growth in places like Pennsylvania by developing new technologies and training the workforce that will do these jobs."

Cleaning up

Winding between Centre and Clearfield counties, Moshannon Creek runs red. A reddish-orange tint stains the stream banks and rocks—a visible sign of acid mine drainage pollution from nearby coal mines.

Acid mine drainage, a common pollution issue in coal communities, occurs when pyrite unearthed by mining activity interacts with groundwater and air and then oxidizes, creating sulfuric acid. The acid then breaks down surrounding rocks, causing toxic metals to dissolve into the water.

"In a lot of these places, the coal was mined sixty, seventy, or eighty years ago," Arnold said.

Photo (upper left): Jesse Martinez, a mining engineering student, places proper identification on all samples prior to analysis for critical minerals and rare earth element content.

Photo (upper right): Sam Davis, an energy engineering student, operates a cross-belt magnetic separator as one step in processing the cores to recover critical mineral and rare earth element concentrates.

Photo (left): Barbara Arnold shows a portion of a core that will be analyzed for critical mineral and rare earth element content.

"Now we can go back in, reclaim some of these waste products, and put the materials back better so we don't have things like acid mine drainage occurring."

Materia USA and Texas Minerals Resource Corporation (TMRC), developers of rare earth and critical mineral projects, have produced conceptual plant designs for the recovery of rare earth minerals from coal waste streams like those in Central Pennsylvania and in the anthracite fields, respectively.

Penn State is partnering with the companies, and researchers have identified elevated levels of REEs in coal overburden and underclays from the areas.

"It's reclamation of land and water," Pisupati said. "That's the idea. We can clean up the land, clean up the water, and reclaim various valuable resources from waste streams and reduce the foreign dependency for these critical minerals for sustainable growth."

Liberate and separate

The DOE estimates there are millions of metric tons of critical minerals in the country's coal waste streams.

But for projects like the Materia USA or TMRC plant to be competitive in the open market, scientists must continue to improve how we extract or separate the valuable materials from waste streams.

Penn State researchers with the Center for Critical Minerals, for example, have developed an innovative process that recovers more rare earth elements and aluminum from acid mine drainage while using a small amount of chemicals.

Adding carbon dioxide to acid mine drainage already being collected in retention ponds produces chemical reactions that result in solid minerals called carbonates forming and precipitating out of the water. The process results in a sludge from which critical minerals can be harvested.

"The success and scale-up of these processes, with collaboration between the Center for Critical Minerals and our industry partners, can result in unlocking significant secondary sources for critical minerals," said Mohammad Rezaee, assistant professor of mining engineering. "We can help address U.S. needs for these materials, improving the environment by re-mining and treating the waste streams, promoting advanced technology and manufacturing, ensuring national security, and providing significant job opportunities."

The Center for Critical Minerals unites over twenty-five faculty members across Penn State's departments and colleges- geosciences, energy and mineral engineering, materials science and engineering, chemistry, chemical engineering, and energy business and finance who conduct cross disciplinary work addressing various challenges around critical minerals.

"This had to be Penn State," Arnold said. "This is our history. This is what we do. This is what we have done. We should be the ones doing this given our rich history in geosciences and mining. That's how Penn State started." ⌘

"American industry will be faced not only with a lack of raw materials at home, but also with the difficulty of obtaining supplies abroad."

~Dean Edward Steidle

Those visionary words, written in 1952 by Edward Steidle, former dean of Penn State's College of Mineral Industries, the predecessor of the present College of Earth and Mineral Sciences, still ring true today, and in response Penn State launched the Center for Critical Minerals in 2019. The center leverages Penn State's existing faculty, facilities, and research strengths to make the University the go-to resource for critical minerals research and technical support for industry.

The center includes scientists from across Penn State whose research expertise can be harnessed to address the issues posed by critical mineral exploration, characterization, separation, and production.

Visit the Center for Critical Minerals online at https://www.c2m.psu.edu

PROXIES OF THE PAST

Chemical clues captured in the rock record open new window into ancient oceans

by Matthew Carroll

Temperatures climbed into the triple digits last summer as the researchers hiked Sawtooth National Forest in southern Idaho. They passed trees charred by a wildfire that consumed more than 90,000 acres in the fall of 2020. Haze hung in the air from another fire that burned out of control hundreds of miles away in Oregon.

Defying the stifling heat, the scientists pressed on, searching for the right place to dig. Under their feet, and below the baking Idaho soil, lies evidence of a time now unrecognizable.

Nearly 300 million years ago, during the Permian period, this place sat at the bottom of a shallow sea. Phytoplankton bloomed on the surface and ancient fish, brachiopods, and sponges thrived.

As these creatures lived, died, and settled on the sea floor over millions of years, they formed deposits captured in the rock record. Kimberly Lau and a team of scientists arrived in Idaho to collect samples and bring them back to Penn State for new analysis that could improve our understanding of what was happening in the oceans of ancient Earth.

"Huge amounts of phosphate were deposited here millions of years ago in an environment we really don't see today—this vast shallow inland sea," said Lau, assistant professor of geosciences. "We hope these samples can shed new light on how environments changed in the deep past and how nutrients and by extension, life, responded."

In the present, increasingly frequent and severe forest fires and rising temperatures—Idaho sweated through its hottest June and July on record in 2021—tell an important story of a changing climate. But understanding environmental changes in Earth's ancient past is also important for predicting how the planet will respond far in the future.

"We can't go back in time and directly measure things like temperature or carbon dioxide concentrations," Lau said. "There are no thermometers to read or ice cores to sample when you go back a million years. Even when we look at rocks, we are taking some incomplete measure of what the environment was like."

Scientists like Lau turn to geochemical clues in the marine sedimentary record to reconstruct environmental changes in the planet's history.

Understanding the availability of nutrients, for example, has critical implications for the health of the oceans—levels that are too low can be insufficient to support a healthy ecosystem, and levels that are too high can result in eutrophication, an excessive richness of nutrients that can lead to oxygen depletion and animal die-offs.

"All we have are these tools called proxies," she said. "And it's our job as geologists to develop them, evaluate them, and make the most accurate and precise interpretations we can."

The Great Dying

Some 250 million years ago, life on Earth nearly came to an end.

Massive volcanic eruptions spurred a chain of events that led to the largest mass dying recorded in history—the end-Permian extinction event. Entire ecosystems collapsed as a catastrophic number of species perished in the oceans and on land.

Top: Scientists measure an outcrop of siltstones and cherts of the Phosphoria Rock Complex, Cassia Mountains, Sawtooth National Forest, Southern Idaho.
Lower: A rock hammer rests on an outcrop of cyclically bedded cherts composed of siliceous sponge spicules of the Phosphoria Rock Complex, Cassia Mountains, Sawtooth National Forest, Southern Idaho

It took more than five million years, into the Middle Triassic period—which eventually gave rise to the dinosaurs—before life approached its former levels of diversity, the longest recovery time from any mass extinction.

When a doctoral student at Stanford in 2016, Lau was lead author on a paper published in the journal Proceedings of the National Academy of Sciences that identified ocean anoxia, or low oxygen conditions, that corresponded with the delayed recovery on a global level.

Lau found ocean oxygen levels plunged globally during the mass extinction and recovered slowly, only approaching their previous conditions after five million years. It was the first evidence showing this beyond a regional scale.

"This was a big extinction event, so you might expect a slow recovery," she said. "But five million years is extremely long. It's still a debate why the Earth system collapsed but then came back and recovered over that time scale. My research showed a really clear pattern that anoxia had a big role in the delay in recovery from the extinction."

Lau was among the first to conduct this type of research using uranium isotopes, an emerging proxy for oxygen levels in past oceans. She measured uranium preserved in marine limestone rocks and found isotope values, expected to be higher in oxygen-rich waters, also dropped during the extinction event and didn't return until biodiversity had risen near its initial levels.

"Dr. Lau has been developing novel proxies of ancient environmental conditions to investigate the relationship between environmental change and the health of the biosphere," said Lee Kump, John Leone Dean in the College of Earth and Mineral Sciences.

Kump, who is also a professor of geosciences at Penn State, collaborated with Lau on the paper.

"As our climate changes and we worry about the effects on life and environments, Dr. Lau's work allows us to see how the biosphere has responded to similar changes in deep time, providing an analog for the future," he said.

At Penn State, Lau has continued her work developing isotopes and geochemical proxies to investigate oxygen levels in ancient oceans, including continued research on the end-Permian, the end-Triassic extinction, and the transition between the Ediacaran period and the Cambrian, when multicellular life exploded.

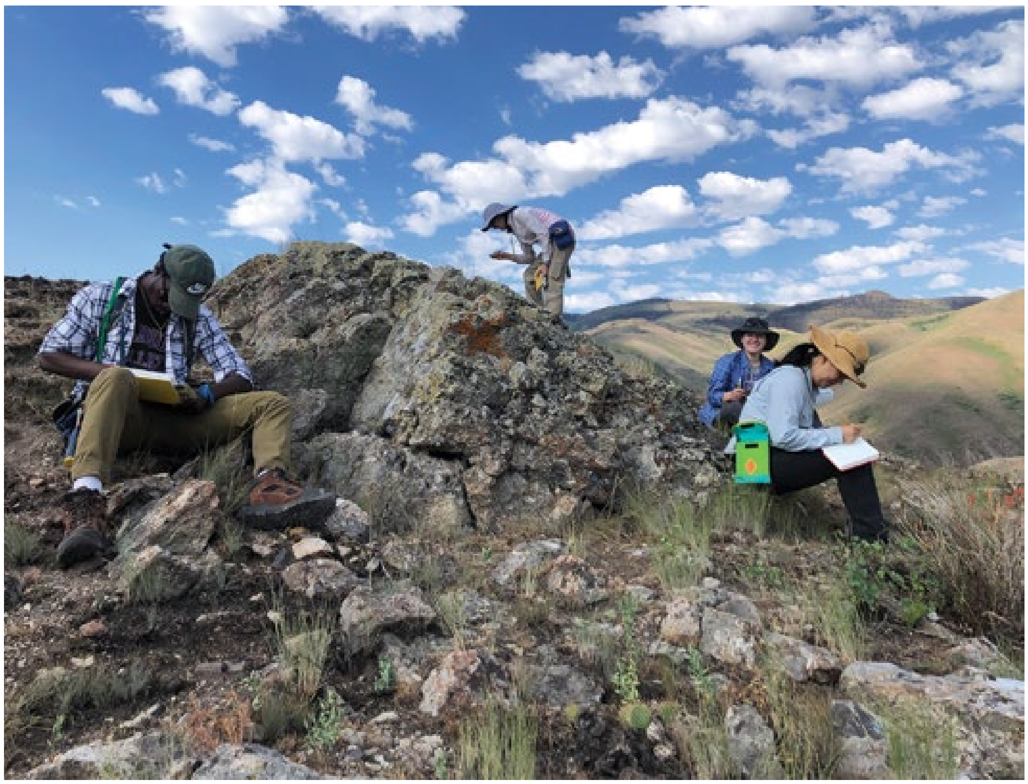
"To this day my research seeks to understand how the Earth has changed in terms of its environments, what causes those changes, and how those changes are linked to the evolution and extinction of life on our planet," she said. "I'm particularly interested in understanding what causes anoxia and how those low-oxygen conditions can be sustained for long periods of time."

A geochemist's life

Last summer, Chelsie Bowman got to be a different kind of scientist. She climbed the mountainous Idaho terrain, dug into hillsides with her rock hammer, and exposed sections of soft rock previously hidden away for millions of years.

"At this point, even though I've been doing this for a decade, my parents still think what I do must be similar to Indiana Jones or Alan Grant from Jurassic Park," said Bowman, a postdoctoral scholar who works with Lau at Penn State. "To start with the basics, we're not looking for dinosaurs."

In reality, geochemists like Bowman and Lau spend much of their time in the laboratory, running complex chemical analysis on rocks that collaborators collected. But last summer, the pair, and researchers from Albion College in Michigan, embarked on the two-week journey to Idaho.



Lau and her feld team examine a breccia outcrop on a peak in the Cassia Mountains, south-central Idaho.

"Because these samples were formed in an ancient ocean basin, we can learn things about the chemistry of those ocean waters based on the chemistry of the rocks we've collected," Bowman said. "We're trying to learn things like how oxygen concentrations might have changed through time and space in the basin we're looking in."

Low oxygen concentrations in the sea are a clue to why large deposits of the nutrient phosphate can form, sometimes over millions of years. Idaho has one of the country's largest reserves—the ore has been mined there for more than a hundred years, mainly for use in fertilizer products.

"Our end goal is to be able to tell a story with our data about random events that happened hundreds of millions of years ago," Bowman said. "Part of that is using as many different lines of proxy evidence as possible to narrow in on what was going on and to make our results as irrefutable as they can be. That's one of the best things about what we do—it's very much like putting a puzzle together."

Today, oxygen-depleted dead zones occur in oceans when nutrient-rich runoff feeds massive blooms of phytoplankton. As these organisms die and sink to the ocean floor, large amounts of microbes break them down and consume most of the available oxygen in the process, starving ocean creatures of what they need to survive.

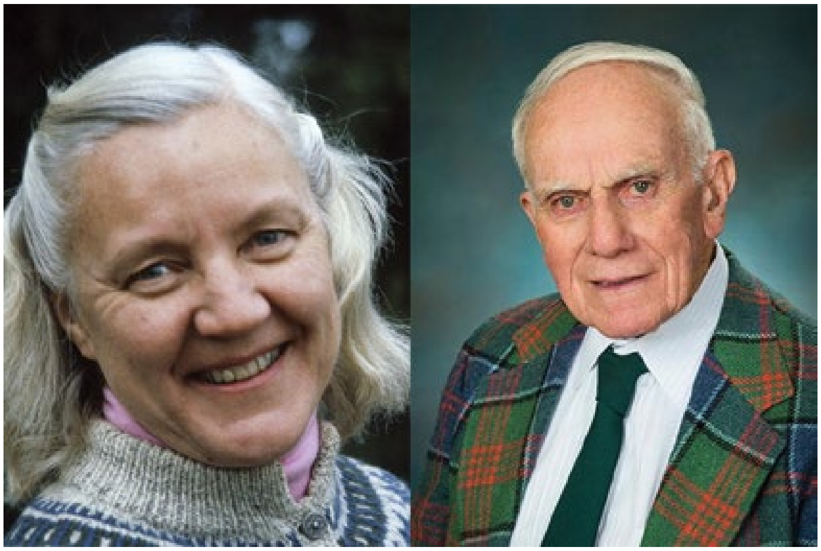
This same process may have played out repeatedly in the deep past, fueled by ocean currents bringing deep, nutrient-rich water to the surface, or from continental weathering, the processes that break down rocks and allow water to transport ions dissolved from minerals once stored inside. More weathering occurs when the planet is warmer and wetter, like in times of high greenhouse carbon dioxide concentrations after a major volcanic eruption.

"Weathering is often called Earth's thermostat," Lau said. "It's how we have maintained habitable conditions for life for almost two billion years. It doesn't happen next year or in ten years. This is a really slow process. That's why understanding how sensitive Earth is to this thermostat activity helps us understand how quickly it can bounce back if something is perturbing it.

"Understanding these ancient events gives us some sense of how the Earth can respond in the future." ⌘

"Understanding these ancient events gives us some sense of how the Earth can respond in the future."

~Kim Lau



Barnes professorship established

A endowed professorship in the Department of Geosciences honors the legacy of husband-and-wife Penn State researchers, one a distinguished professor emeritus in the department.

The Dr. Hubert Barnes and Dr. Mary Barnes Professorship in Geosciences was funded with a $1 million gift from the Barnes family. Hubert Barnes, distinguished professor emeritus, was a world-renowned geochemist who spent thirty-seven years as a professor at Penn State. Hu Barnes died on Aug. 4, 2022. Mary Barnes, who died in 2017, worked as a research associate in the Materials Research Laboratory.

“Penn State provided an environment that stimulated productivity throughout our careers,” Hubert Barnes said in a 2022 interview. “We both believed this endowment is a fitting means of acknowledging this support and to further the work of the extraordinary faculty of the geosciences department. There are reasons that our department is ranked among the foremost of the world, and the evidence of that is our inspired colleagues.” https://bit.ly/3x4LKNs

Department associate heads appointed to amplify diversity efforts

Furthering its mission to support diversity, equity, and inclusion (DEI), associate heads for DEI were appointed in each of the college’s five departments. They will lead department DEI efforts and coordinate with the college to support and deepen the work being done by the college’s Office of the Associate Dean for Educational Equity.

“These faculty members are providing an important service to their departments and the college in leading DEI efforts and in fostering a sense of belonging for all our faculty, staff, and students,” said Victoria Sanchez, associate dean for educational equity in EMS.

The associate heads are Eugene Clothiaux, professor of meteorology and atmospheric science; Lorraine Dowler, professor of geography; Enrique Gomez, professor of chemical engineering and materials science and engineering; Elizabeth Hajek, associate professor of geosciences; and Chiara Lo Prete, associate professor of energy economics.

https://bit.ly/3AedBti

Video: Lee Kump shares perspective on diving and discovery

In a video series titled “Perspective: Leaders at Penn State,” Lee Kump, John Leone Dean, shares his insights on how an early interest in diving has not only turned into a lifelong passion but helped foster a love for discovery. He reflects how it’s important to him to help students chart their own paths — and how Penn State makes that possible.

Learn how Kump draws inspiration from diving, helping to provide powerful experiences for students to get out into the water and follow their passions.

https://bit.ly/3wXweTJ

Ryan Family Student Center finds ways to make students feel at home despite COVID-19 challenges

The pre-semester experience known as Total Engagement with EMS (TEEMS) links new students with upper-level student mentors, faculty, staff, and alumni even before classes begin. With ongoing concerns about COVID-19, the college worked hard to make the return to an in-person, three-day event held in August at Lake Raystown a success.

"TEEMS was especially helpful in making this big University feel like a small, tight-knit community that I could be a part of," said Kaitlyn Zajkowski, a first-year student majoring in materials science and engineering. "It put all of the fears aside that I had about going to a big university. It helped me feel welcome and confident as I start my new chapter."

Given the success of TEEMS, when a request for proposals came out to provide funding for experiences for second-year students, the Ryan Family Student Center staff knew exactly what they wanted to do. In the middle of TEEMS, they huddled around a picnic table and wrote a proposal for TEEMS 2.0, a one-day, in-person event held in September at Lake Raystown for current second-year students who were offered only a virtual version of TEEMS in 2020 owing to the COVID-19 pandemic. While the virtual experience was effective, they wanted to give students a taste of the same in-person experience.

TEEMS 2.0 was well timed for students like Bassam Alhazzani. The sophomore majoring in petroleum and natural gas engineering, who is a sponsored student through Saudi Aramco, arrived at Penn State from Saudi Arabia in 2020 and found himself gaining less of the student experience than he had hoped for. He said the event was just what he needed to make connections and to start reaching out and joining clubs and getting involved on campus.

https://bit.ly/38lrj4N

Grant to improve geology, technology, art collection storage

A grant from the Institute for Museum and Library Services will help the museum care for items such as its historic meteorological instruments, which are part of the museum's vast collection of vintage technology and safety equipment.

The Earth and Mineral Sciences Museum & Art Gallery has secured the fourth in a series of grants totaling $450,000 from the Institute for Museum and Library Services, which will be used to continue the effort to securely store some of the museum's collections.

Specifically, the grant will allow staff to finish storage for the geology collections with high-end cabinetry designed to protect items from deterioration. It will also fund the beginning stages of securing the museum's technology collection, which includes historic mining safety gear, cartography tools, meteorological instrumentation, and industrial glass-making equipment.

Julianne Snider, director of the museum and art gallery, said the museum's technology collection includes artifacts such as first University president Evan Pugh's personal laboratory equipment as well as items to advance safety in the mining industry. Many of the items, she said, help tell the story of the college and also the history of the state. https://bit.ly/3je2PwF

Researchers look to build on Deines legacy in lab named in his honor

(Left to right): Lora Weiss, senior vice president for research, former President Eric Barron, Melissa Deines, wife of the late Peter Deines, Katherine Freeman, Evan Pugh University Professor of Geosciences, Andrew Nyblade, head of the Department of Geosciences, and Lee Kump, John Leone Dean in the College of Earth and Mineral Sciences, cut the ribbon to mark the naming of the Deines Lab.

The Peter Deines Isotope Mass Spectrometry Laboratory was dedicated fall 2021 in a ribbon-cutting ceremony. The facility, which is housed in a newly renovated portion of the basement of the Deike Building, features state-of-the-art equipment designed to benefit the research of the geosciences department and beyond. The lab features a large suite of instruments that can analyze isotopes within a wide array of molecules and minerals.

"Peter Deines represented the best of what a Penn State faculty member has to offer, and he is missed by those of us who were lucky to know him," said Katherine Freeman, Evan Pugh University Professor of Geosciences. "But his scientific legacy at Penn State is already being carried forward by a new generation of geochemists who are precisely measuring all kinds of isotopes in all kinds of samples. I am genuinely delighted that they can now do so in a space that bears his name."

https://bit.ly/3tZyrfB

Celebrating 125 Years

Celebrating
125
YEARS
1896 – 2021

In 2021, the College of Earth and Mineral Sciences celebrated its quasquicentennial—the 125th anniversary— of its founding in 1896.

A number of celebrations were held beginning in the fall of 2020 and continuring throughout 2021 to commemorate the 125th anniversary. Events such as honorary lectures and speaker series were held virtually due to COVID-19. A number of them were recorded and are available to view online. Please visit www.ems.psu.edu/125Anniversary to learn more.

The Founding Years


A mineralogy laboratory class in the 1890s.

The College of Earth and Mineral Sciences boasts a long and distinguished history, one that started in 1859 with the University's first earth sciences courses offered in the agricultural program and stretches today to the borders of the Commonwealth, the nation, and beyond.

The college officially was founded in 1896 as the School of Mines, with three faculty members offering classes in mining, metallurgy, and economic geology to twenty-two students.

From those beginnings, it has evolved into an outstanding college with highly ranked academic programs, a significant research enterprise, world renowned faculty, superb students, talented staff, and nearly 28,000 alumni. From the vision and commitment of the founders, the college has grown during the last 125 years and produced more than a century of noteworthy accomplishments.

See our rankings: www.ems.psu.edu/about/our-excellence/rankings.

125th Anniversary Fellows Named

The College of Earth and Mineral Sciences recognizes that the success and reputation of the college is defined substantially by the achievements of its graduates. To honor their accomplishments the college has selected a prominent group of alumni whose contributions to the fields of science and engineering have set them apart from their peers and named them 125th Anniversary Fellows. View list of Fellows: https://bit.ly/3RAKiKO

New dates: Celebration of Accomplishment weekend

The Celebration of Accomplishment: 125 Years of Earth and Mineral Sciences, which was postponed due to COVID-19, has been rescheduled for Friday, October 14, and Saturday, October 15, 2022.

Weekend festivities will include the 125th Anniversary Fellows Reception, open houses, and tours. As details are confirmed, information will be posted online: https://bit.ly/3v5GmI9.

Building on our history…

As we mark our college's 125th Anniversary, we continue a strong tradition started more than a century ago of building deep disciplinary expertise along with interdisciplinary teams that focus on the interfaces of the natural science, social science, and engineering disciplines, where answers to the most pressing problems facing society await discovery.

At the heart of the college is a spirit of community, engaging our students and alumni in all that we do, seeking always to create a culture of inclusivity and belonging for all, while reaching out to industrial, governmental, and community partners to identify important problems and design solutions.

Moving forward, we see that the world is in transition, and the college is in transition as well. Basic research continues as the cornerstone of innovation, while our faculty and staff actively pursue the translation of research discoveries and advances to the direct benefit of society, including engagement with local, state, national, and international stakeholders. Interdisciplinary research remains the hallmark of the college, and its importance is elevated in a world in transition.

The ways that we collaborate and the tools that we use to further our mission are also changing, and we need to create new spaces to support these novel approaches. As we manage these transitions, we need to sustain and expand our leadership position, at the University and beyond, drawing upon those attributes and traditions that make the college great: agility, creativity, interdisciplinarity, collegiality, inclusivity, and an unwavering focus on quality. In all that we do, the safety and well-being of our community must be a precondition for excellence.

Planning for the next chapter

These transitions demand a new, innovative strategic plan for the college, one that stays true to our mission, manages our own transitions, and guides those of our stakeholders. Our strategic plan is centered on four principal goals:

1. Promote curricular and co-curricular innovation to grow active, engaged and competency-based learning with a focus on career readiness.
2. Build a more diverse, equitable, compassionate, and inclusive community of scholars, where members share a sense of belonging and respect.
3. Perpetuate and expand the role the college plays as an innovator and leader in signature initiatives at the University and beyond.
4. Improve operational resilience and critical infrastructure for research, educational, and outreach initiatives.

Read our Strategic Plan: https://bit.ly/3Pymci3

The mission of the College of Earth and Mineral Sciences is to advance knowledge, talent, and leadership to elucidate Earth processes and history, harness and sustain natural resources and materials, and develop novel solutions to major challenges in energy, environment, and well-being.

Note: all photos in this section from college or University Archives .

Obelisk built by EMS as a teaching tool

Constructed in 1896, the same year the college was established, the obelisk consists of 281 blocks of building stone from 139 different localities, mostly in Pennsylvania. Its components are arranged to represent the geologic column of the rocks of Pennsylvania, with the oldest rocks at the bottom and the youngest at the top.

Early view of the Obelisk located along the Mall in by the former Armory.

Magnus C. Ihlseng, Penn State's first professor of mining engineering and geology and our college's first dean, initiated its construction. He desired to create an instructional yet artistic monument which would test the weathering qualities and commercial value of Pennsylvania's building stones. He employed freshman William Clinton B. Alexander to secure stones from around Pennsylvania.

Magnus C. Ihlseng

In a letter to President Atherton, after its completion, Ihlseng wrote, "It exhibits many of the varieties of structural material with which Pennsylvania is endowed and reveals to the architect at a glance the possibilities of artistic combinations from our native products...Thus the column is not only picturesque but exceedingly valuable to student, visitor, and artisan." Professor Ihlseng considered the obelisk to have been the college's "greatest single expenditure for the year"—$708.09.

Today the Obelisk is the symbol of a society that honors major contributions to the college and whose members reflect their commitment to the continuing achievement of the college through their generosity.

Information from: T.C. Hopkins in the Mining Bulletin, Vol. III, No. 2, March 1897 and John Elliot Allen in Mineral Industries, Vol. 18, No. 6, March 1949

Blue Band origins traced to Cadet Band formed by EMS alum

Deike (front row, left) and the five other students in the Cadet Band, refered to as the "Original Six."

The Blue Band can trace its origin to a Cadet Band formed by EMS alum George Deike in 1899.

As a member of the corps of cadets, Deike lived in the cadets' dormitory. The Commander of Cadets, Captain Taliaferro noticed the bugle hanging on the wall above Deike's bunk. Questioned about it, Deike replied that he had served as his unit's bugler during his service in the Spanish-American War.

Taliaferro saw in Deike an opportunity. He charged Deike with the task of finding and assembling a military band to provide the necessary cadence for the cadets' drill. Deike recruited five of his fellow cadets and formed a drum and bugle corps that connects in an unbroken line to the Penn State Blue Band we have today.

“Old Mining Building”

In 1906, the School of Mines expanded and was renamed the School of Mines and Metallurgy. Since the school had outgrown its quarters, a new site was chosen for the erection of a new building to house the growing school. The building, erected on the site occupied by the current power plant on College Avenue, was called the Old Mining Building.

The cost was defrayed by a gift of $5,000 from Andrew Carnegie. In 1907, the state legislature appropriated $20,000 to enlarge the building.

Largest program in the East

In the first decades of the 1900s, funding was scarce and graduating classes were small, but by the late 1920s, with 126 students, the School of Mines and Metallurgy was the largest mineral industry program in the East and the second largest in the United States.

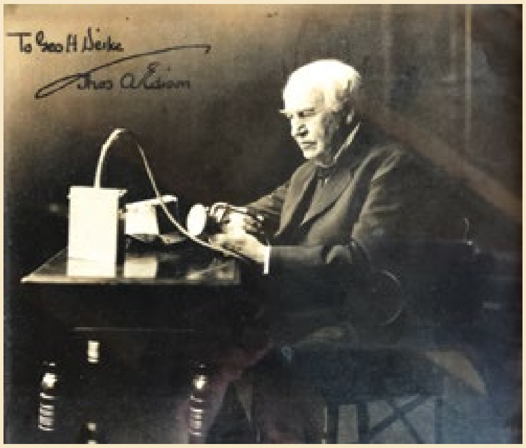
Left photo: Mineralology class, meeting in the Old Mining Building in the late 1920s, identifying rock specimens.

Legacy of the Deike and Ryan families

The names Deike and Ryan may be familiar to Penn Staters; each have facilities named in their family’s honor on the University Park campus—the Deike Building and the Ryan Family Student Center, the college’s advising, tutoring, and social hub—named in honor of their long-lasting ties to the college and University.

George H. Deike Sr. received his degree in mining engineering in 1903 and John T. Ryan Sr. earned his degree in mining engineering in 1908. In 1914, the two partnered to form Mine Safety Appliances in Pittsburgh, Pennsylania. Recognizing the critical importance of dependable, safe mining equipment, they enlisted Thomas Edison to help them create a dependable and safe electric cap lamp. The creation, known as the Electric Cap Lamp, ultimately made the open flame lamp obsolete, greatly reducing fatal explosions. Over the next twenty-five years, mine explosions were reduced by 75 percent, saving many lives. Edison would later say in life that of all his inventions, this was the one that did the most for humanity.

Ryan and Deike each had sons—John Ryan Jr. and George Deike Jr.—who would go on to get their mining engineering degrees from Penn State and continue in their fathers’ footsteps by focusing on improving mine safety. Deike Jr. and Sr. also played a strong role in Penn State’s development by serving on the Board of Trustees; together, the two served for fifty-one years total. George Deike Jr. and Sr. and John Ryan Jr. received the Penn State Alumni Association’s Distinguished Alumni award in recognition of their accomplishments. George Deike Jr.’s wife, Anne B. Deike, endowed the first professorship in the College of Earth and Mineral Sciences in 1998.

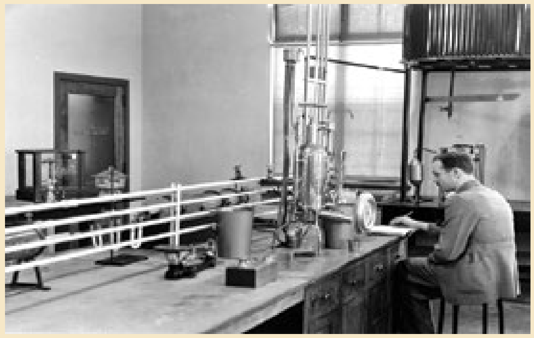


Signed photo of Edison with the Electric Cap Lamp.

Early classes and research















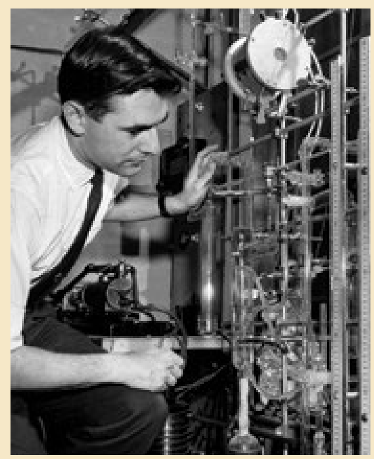
Photos (left to right): Row 1: mining class of 1903, group of students in 1914, surveying in 1922. Row 2: carbonizing steel in 1930, fuel technology lab in 1930, ceramic science class in 1930. Row 3: Raymond Murphy, first geographer on faculty teaching in 1933, weather balloon launch in 1937, David McFarland, head of metallurgy, teaching in 1937. Row 4: Conducting a magnetic survey in 1940, measuring radioisotopes for oil and gas in 1946, ceramics lab in 1948, cartography studies in 1948. Row 5: preparing to launch weather balloon in 1948, studying fossils in mapping the Bedford quadrangle project in 1949.







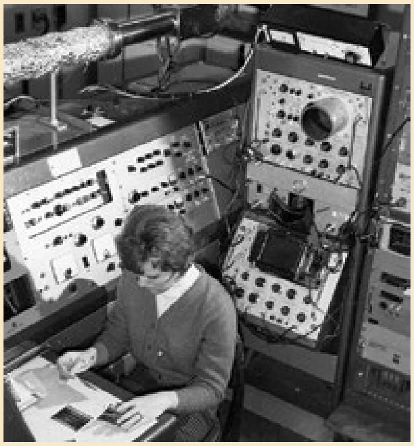


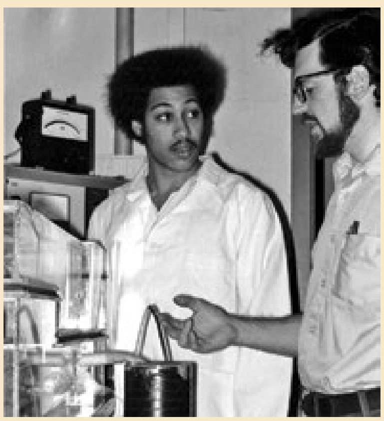


Photos (left to right): Row 1: students lined up to receive rock kits in the 1950s, student at Field Camp in 1950, research using the vertical seismograph in 1950. Row 2: students in petroleum and natural gas in lab, conducting an electormagnetic survey in 1951. Row 3: Della Roy, research assistant in geochemistry, investigating mineral synthesis at high pressures and temperatures in 1952, field work measuring the pull of gravity, metallurgy students working in the metals lab in 1956, research using gas handling system used in extracting oxygen from synthetic materials in 1957. Row 4: measuring ratio of heavy to light oxygen using mass spectrometer, which was developed by Penn State, researchers using single crystal gonimeter, which shoots x-rays at crystals to obtain diffraction patterns in 1959.

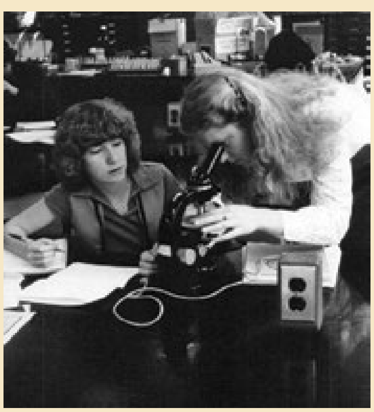


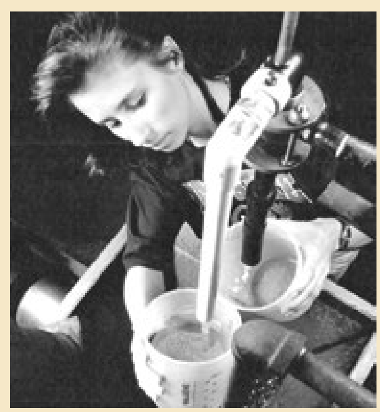












Photos (left to right):
Row 1: Hans Panofsky and student measuring ozone content of stratosphere on the Dobson Spectrophotometer in 1959, field camp in Montana in 1961 (first time held outside of Pennsylvania), group of students in 1957. Row 2: squeezing oil from coal in 1970, using computer for research in 1970, students working in cartography lab under the supervision of C. Greg Knight in 1974. Row 3: John Trent with polymer science professor in 1974, student polishing rocks in lapidary lab in 1979, two students in cartography lab in 1982, student working on atomic-probe field-ion microscope in 1982. Row 4: students using optical microscopes to examine thin sections of minerals and rock in 1982, student operating electron microscope with aid of adviser in 1983, mineral processing student using sludge cyclone in 1995.

Steidle, a man of vision

Edward Steidle, a man of great energy and vision, became dean in 1928. Under his leadership, many new programs and facilities were inaugurated. One of his first actions was to change the name of the school to the College of Mineral Industries in a successful attempt to offer a broader curriculum, as well as give it more credibility. In 1966, the name was changed to the College of Earth and Mineral Sciences by Dean Charles Hosler.

Steidle emphasized the development of strong programs that embraced all of the mineral sciences. He included what where then uncommon university disciplines such as geochemistry, geography, meteorology, and mineral economics. By his retirement in 1953, Dean Steidle had seen the undergraduate enrollment grow from 144 to 590, the graduate enrollment from none to 170, and the faculty from 15 to 60.

Under his guidance, the School constructed the Mineral Industries Building in 1930, now named the Steidle Building, and the Mineral Sciences Building, in the late 1940s, now named the Hosler Buildling.

1929 rendering of the then proposed Steidle Building, signed by architect Charles Z. Klauder who designed many early Penn State buildings, The iconic rotunda and portico beautifully illustrate Klauder's Beaux-Arts style.

Above photo: Breaking ground for Steidle Building in 1929. Former Armory shown on the the right of photo and Carnegie and Sparks Buildings are shown to the left.
Left photo: Hosler Building (right side of photo) being built in 1948 with the recently constructed Steidle Building in the center. Left side of photo shows the Willard Building under construction.

Steidle Collection of American Industrial Art

The EMS Museum & Art Gallery holds one of the country's most extensive collections of paintings and sculpture depicting mining and similar industries—the Steidle Collection of American Art. Established in the 1930s by Steidle, the collection has been described as "a time capsule that allows us to observe the relationships among the fine arts, industry, and education in America in the years before World War II."

Steidle believed art reflected life and experience. He commissioned and collected artwork that depicted Pennsylvania's extractive industries. He used the art as dynamic and aesthetic education tools to build awareness of the importance of minerals to human existence. By exhibiting art with specimens of Earth materials and objects of technology, Steidle positioned the EMS Museum & Art Gallery to protect and project the history of science, technology, research, and teaching that takes place in the college.

The collection continues to grow and currently includes more than 250 paintings, prints, drawings, watercolors, and sculptures representing the work of 130 artists, 29 of whom are women.

View the collection online at https://bit.ly/3QzbXKQ

Dean Steidle (left) with the 1846 painting *Rolling Steel Ingots, Richards Foundry* by George C. Bingham.

Long history of diversity

Penn State is committed to and accountable for advancing diversity, equity, and inclusion in all of its forms and diversity, equity, and inclusive excellence play a central role in the college's core mission to prepare its students to live, work, and lead in a global environment. The college aims to provide all students with a world-class education. By fostering an environment that values diversity, the college hopes to help all students find their place in the college.

The college has a long history of diversity but more work is needed. The college has increased the diversity of our students. Women now comprise 31 percent of the college's undergraduates; 9 percent are from underrepresented minorities; and 21 percent are international students.


PENNA., SATURDAY, OCTOBER 20, 1934

First Girl in Penn State's Mineral Industry Course

Alexandra Tillson with Dean Edward Steidle.

Alexandra Tillson Filer

Alexandra Tillson Filer, who graduated in 1938, was the first woman to graduate from Penn State with a degree in metallurgy. In a 2014 interview she said, "The graduating class in metallurgy that year was small, just myself and seven young gentlemen."

Filer had to overcome much opposition to women studying science and engineering. She remembers quite vividly that when she went to her first metallurgy class, the professor said "What the hell are you doing in my class! Obviously he wasn't expecting a girl in his metallurgy class, even though my name was on the attendance sheet! He must have thought that my name 'Alexandra' was misspelled and was supposed to be 'Alexander' and was another male student."

Her career at Penn State spanned more than fifty years. She was a founding member of the Penn State Materials Research Laboratory, now the Materials Research Institute. She was the first female materials scientist and the first Penn State woman to be inducted into the National Academy of Engineering. When her husband, Rustum, was also inducted, they became the first spousal coupled to be so honored.

The mineral Dellaite was named after her in 1965. She is one of only 112 women to have a mineral named after them as of May 2019. She died in 2021.

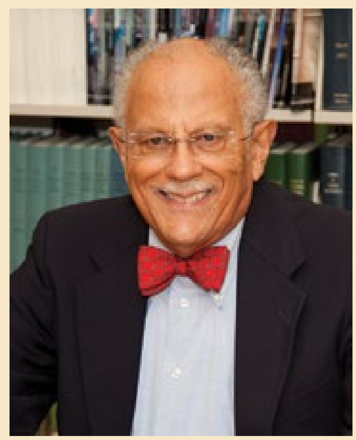
Della Roy in 1952

Della Roy

Another pioneer was Della Roy, professor emeritus of materials science. She earned her master's degree in minerology in 1949 and her doctorate in mineralology in 1952.

She was a pioneering scientist who laid the foundations for the development of lower-CO_2 emission production methods of cements

Warren Washington



Warren Washington earned his Ph.D. in meteorology from Penn State 1964, making him the second African-American to earn a Ph.D. in meteorology nationwide.

Warren is often referred to as the father of climate modeling. In the early 1960s, he recognized the potential of computers to revolutionize our understanding of Earth's climate and helped develop the first-ever computer models to study the effects of atmospheric carbon dioxide concentrations on global temperatures. His groundbreaking work advanced the field of numerical climate modeling, allowing scientists to predict future atmospheric conditions and better understand climate change.

In 2007, he contributed to the IPCC report, which was awarded Nobel Peace Prize; was awarded the 2010 National Medal of Science from President Barack Obama; and was co-recipient of the Tyler Prize in 2019.

He advised six consecutive U.S. presidents—from Jimmy Carter through Obama—on climate change.

In 2019, the University honored him by naming the Warren M. Washington Building in Innovation Park after him.

College leadership then and now

Photo of college deans taken in 1966. Left to right: Charles Holser (1965-85), Richard Jahns (1962-65), Frank Tuttle (1959-60), Edward Steidle (1928-53), Elburt Osborn (1953-59), and David Mitchell (1960-62).

Photo of college deans taken in 2019. Left to right: Lee Kump (2017-present), William Easterling (2007-17), Eric Barron (2002-06), John Dutton (1985-02), and Charles Hosler (1965-85). Barron served as President of Penn State from 2014 to his retirement in May 2022.

Left to right: Zuleima Karpyn, associate dean for graduate education and research, Yvette Richardson, associate dean for undergraduate education, Victoria Sanchez, associate dean for educational equity, and Annie Taylor, assistant dean for distance learning.

Earth and MINTeral Sciences Bittersweet Mint

Penn State Berkey Creamery Flavor of the Month

In honor of the College of Earth and Mineral Sciences' 125th Anniversary, the college partnered with the Penn State Berkey Creamery to sponsor the popular flavor, "Bittersweet Mint," as "Earth and MINTeral Sciences Bittersweet Mint" from August to October.

"We chose the mint flavor—"Earth and 'MINTeral Sciences"—because we are the college where new ideas and discoveries in energy, environment, and materials are 'minted' into just, equitable, and sustainable solutions for society," said Dean Lee Kump.

The partnership is part of the Creamery's flavor sponsorship program, which can support the temporary renaming of a flavor, according to Jim Brown, assistant manager of Creamery operations.

"As with all our flavor sponsorship programs, the Creamery hopes to build awareness that the Creamery is much more than ice cream," Brown said. "We are what Penn State is all about: community, tradition and pride."

https://bit.ly/3dWLzfU

Dean Lee Kump serves up Earth and MINTeral Sciences Bittersweet Mint at the Penn State Berkey Creamery.

"A Greater Penn State for 21st Century Excellence"

Greater, Together

Philanthropy—support from private individuals, families, and leaders who believe in the University's mission—has always been vital to our success in fulfilling the University's land-grant values.

On July 1, 2016, Penn State launched an ambitious vision for the future of our institution focused on three core imperatives of a public university: Open Doors, Create Transformative Experiences, and Impact the World.

This six-year fundraising campaign, named "**A Greater Penn State for 21st Century Excellence,"** has been an overwhelming success. The University surpassed its $2.1 billon goal, raising $2,204,949,028.

The college also surpassed its goal—twice—raising **$158,036,613**, including $27,857,405 for Open Doors, $1,925,935 for Create Transformative Experiences, and $121,161,734 for Impact the World.

A total of 3,100 gifts were given to support the college's campaign, including gifts from 2,273 alumni and 827 friends, in addition to corporate partners, foundations, and organizations. Such success would've been unthinkable without your help.

Campaign Highlights

Original 2016 Goal:
$67 million
Surpassed in May 2019

Second Goal:
$110 million
Surpassed in February 2021

125th Anniversary Goal:
$125 million
Surpassed in September 2021

Campaign Total:
$158+ million

Every Gift Makes a Difference

Every gift to Penn State starts and ends with an individual. Although we measure campaign progress by the dollars raised, we measure impact by the stories, ideas, and possibilities that exist because of giving.

If you have any questions, please contact Chris Brida, director of development and alumni relations, by email at cmb273@psu.edu or by telephone at 814-867-2592 to explore providing philanthropic support.

Lee Kump, John Leone Dean, reveals the campaign total as of April 24, 2022, to the EMS Development Council members.

Note: numbers through June 30, 2022

Photo: Pixabay

Barbara Arnold, professor of practice in mining engineering, was awarded honorary membership in the American Institute of Mining, Metallurgical, and Petroleum Engineers.

Luis Ayala, William A. Fustos Family Professor in Petroleum and Natural Gas Engineering, received the 2022 Howard B. Palmer Faculty Mentoring Award. He was also named 2021-22 Big Ten Academic Alliance Program Fellow and a 2022-23 Penn State Administrative Fellow.

Allison Beese, associate professor of materials science and engineering, was named director of Penn State's Additive Manufacturing & Design Graduate program.

Susan Brantley was named the inaugural recipient of the Dr. Hubert Barnes and Dr. Mary Barnes Professorship in Geosciences. She was elected a 2021 member of the American Academy of Arts and Sciences, and a foreign associate of the French Academy of Sciences. She was also named an Evan Pugh University Professor by Penn State.

Guido Cervone, professor of geography and meteorology and atmospheric science, was elected president-elect of the Natural Hazards Section of the American Geophysical Union and will begin a two-year term as president in 2023. He was also named to AGU's inaugural Local Science Partners program.

Long-Qing Chen, Hamer Professor of Materials Science and Engineering, received the 2022 FMD John Bardeen Award from the Minerals, Metals & Materials Society.

T.C. Mike Chung, professor emeritus of materials science and engineering, was named a 2021 Fellow of the National Academy of Inventors.

Ralph Colby, professor of materials science and engineering, received a 2022 Faculty Scholar Medal for Outstanding Achievement from Penn State.

Derek Elsworth, professor of energy and mineral engineering and geosciences, was selected as the inaugural G. Albert Shoemaker Chair in Mineral Engineering.

Hamid Emami-Meybodi, associate professor of energy and mineral engineering, received the Quentin E. and Louise L. Wood University Endowed Fellowship in Petroleum and Natural Gas Engineering.

Jenni Evans, professor of meteorology and atmospheric science and Director of the Institute for Computational and Data Sciences, was recognized as a university fellow by Monash University in Melbourne, Australia.

Maureen Feineman, associate research professor and associate head for undergraduate programs in geosciences, received the Schreyer Honors College Excellence in Advising Award.

Christopher Fowler, associate professor of geography and director of the Peter R. Gould Center for Geography Education and Outreach, was named by Governor Tom Wolf to the Pennsylvania Redistricting Advisory Council.

Katherine Freeman, Evan Pugh University Professor of Geosciences, received the 2021 Arthur L. Day Medal from the Geological Society of America.

José Fuentes, professor of meteorology, was appointed as a co-chair of a NSF external advisory committee tasked with assessing and envisioning the future of the Established Program to Stimulate Competitive Research (EPSCoR). He also was awarded a Fulbright Scholar Award for the 2022-23 academic year.

Christopher House professor of geosciences and director of the NASA Pennsylvania Space Grant Consortium, was appointed director of the Consortium for Planetary and Exoplanetary Sciences and Technology. Hesucceeds James Kasting, Evan Pugh University Professor of Geosciences who is retiredafter nearly 35 years at Penn State.

Joshua Inwood, professor of geography, received the 2022 Media Achievement Award from the American Association of Geographers.

Russel Johns, professor of petroleum and natural gas engineering and holder of the George E. Trimble Chair in Earth and Mineral Sciences, received the 2022 Improved Oil Recovery (IOR) Pioneer Award from the Society of Petroleum Engineers.

Zuleima Karpyn, associate dean of graduate education and research and professor of petroleum and natural gas engineering, was named the inaugural Donohue Family Professor.

Beth King, associate teaching professor and assistant program manager of the online geospatial education program, received the 2021 Carolyn Merry Mentoring Award from the University Consortium for Geographic Information Science.

Brian King, professor of geography, was appointed head of the Department of Geography, in July 2021. He succeeded Cynthia Brewer who held the position since 2014.

Lee Kump, John Leone Dean in the College of Earth and Mineral Sciences, was elected to the National Academy of Sciences.

Kimberly Lau, assistant professor of geosciences, received the Pre-tenure Excellence Award from the Geobiology and Geomicrobiology Division of the Geological Society of America. She also was selected to receive GSA's 2022 Young Scientist Award, known as the Donath Medal.

Sukyoung Lee, professor of meteorology, was elected as a 2021 Fellow of the American Geophysical Union. She was also named a distinguished professor.

Shimin Liu, Joseph Kreutzberger Early Career Professor and associate professor of energy and mineral engineering, was recognized as a rising star. by the international journal *Energy & Fuel*.

Zi-Kui Liu, Dorothy Pate Enright Professor of Materials Science and Engineering, was named a Fellow of the Minerals, Metals and Materials Society.

Jennifer Macalady, professor of geosciences, was appointed director of Penn State's Ecology Institute.

Michael Mann, distinguished professor of atmospheric science, was selected as the 2022 recipient of the Leo Szilard Lectureship Award from the American Physical Society.

Paul Markowski, professor of meteorology and atmospheric science, was named a distinguished professor.

John Mauro, professor of materials science and engineering, was named as a Fellow of the National Academy of Engineering and was awarded a 2021 Penn State Faculty Scholar Medal for Outstanding Achievement from Penn State. He was also appointed a Dorothy Pate Enright Professor.

Kwadwo Osseo-Asare, distinguished professor of materials science and engineering and energy and geo-environmental engineering, received the Materials Research Society's 2022 MRS Impact Award.

Mark Patzkowsky, professor of geosciences, was awarded a Fulbright Scholar Award for the 2022-23 academic year.

Clive Randall, director of the Materials Research Institute and professor of materials science and engineering, was named a distinguished professor. He was also named a 2021 Fellow of the National Academy of Inventors and a 2022 Fellow of the Institute of Electrical and Electronics Engineers.

Joan Redwing, professor of materials science and engineering, was named a distinguished professor.

Mohammad Rezaee, assistant professor of mining engineering, was appointed a Centennial Early Career Development Professor in Mining Engineering. He also was named a 2021-22 Henry Krumb Lecturer by the Society for Mining, Metallurgy & Exploration.

Yvette Richardson, associate dean for undergraduate education, was elected to the University Corporation for Atmospheric Research Board of Trustees for a 3-year term, in February 2022.

Joshua Robinson, professor of materials science and engineering, received a 2021 Faculty Scholar Medal for Outstanding Achievement from Penn State.

Karen Schuckman, associate teaching professor of geography in the John A. Dutton e-Education Institute, was appointed as the executive director of the American Society for Photogrammetry and Remote Sensing (ASPRS).

Brandon Schwartz, assistant research professor in energy and mineral engineering, received the Dr. N.G.W. Cook Ph.D. Dissertation Award from the American Rock Mechanics Association.

Susan Sinnott, head of the Department of Materials Science and Engineering, received a 2022 Faculty Scholar Medal for Outstanding Achievement from Penn State.

Erica Smithwick, professor of geography, was named a distinguished professor. She also was appointed as a 2021-22 Penn State Administrative Fellow.

Sanjay Srinivasan, head of the John and Willie Leone Family Department of Energy and Mineral Engineering, was honored as a 2021 distinguished member by the Society of Petroleum Engineers.

Alan Taylor, professor of geography and ecology, was appointed interim director of the Earth and Environmental Systems Institute.

Timothy White, research professor in the Earth and Environmental Systems Institute, was elected a 2021 Fellow of the Geological Society of America.

Karl Zimmerer, E. Willard and Ruby S. Miller Professor of Environment and Society Geography, was awarded a Fulbright Scholar Award for the 2022-23 academic year.

Donohue and Ramani honored with Distinguished Alumni Award

David Donohue, founder and president of International Human Resources Development Corporation, was one of eight Penn State alumni selected to receive the Distinguished Alumni Award in 2021, and Raja V. Ramani, professor of mining and geo-environmental engineering emeritus, was one of eight selected in 2022. The award is the University's highest honor presented to its alumni.

Donohue earned his doctorate in petroleum and natural gas engineering from Penn State in 1963. He later received a juris doctor degree from Boston College Law School in 1971. While he was in law school, he formed IHRDC and, soon after being admitted to the bar, started Arlington Storage Company, the first independent developer of underground gas storage facilities in the United States.

Ramani earned his bachelor of science degree in mining engineering with honors in 1962 from the Indian School of Mines. He joined Bengal Coal Co. before immigrating to the United States to earn his master of science degree in 1968 and doctorate in 1970, both in mining engineering from Penn State.

Ramani joined the Penn State faculty in 1970 and spent more than 50 years at the University. He served as head of the Department of Mineral Engineering, now the John and Willie Leone Family Department of Energy and Mineral Engineering, from 1987 to 1998. In 1998, he was appointed as the George H. Jr. and Anne B. Deike Chair in Mining Engineering.

Meteorology team wins Robertson award

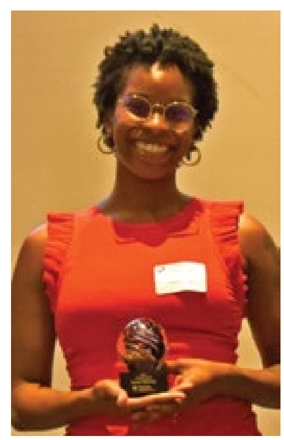
The Paul F. Robertson Award for EMS Research Breakthrough of the Year was created in 2012 with support from a generous gift by EMS alumnus Paul F. Robertson. The award recognizes research achievements over the previous year.

The 2022 recipient was a team of four researchers in the Department of Meteorology and Atmospheric Science: William Brune, distinguished professor of meteorology; David Miller, assistant research professor; Patrick McFarland, student in the IUG program; and Jena Jenkins, graduate student.

Brune and his team identified a new pathway for the production of the hydroxyl radical —OH—in the atmosphere. It is critical to the oxidation capacity of the atmosphere and acts to cleanse the atmosphere of airborne pollutants, yet the sources of this radical have been difficult to clearly define. Thanks to the team's research we now know that lightning produces significant amounts of OH and this greatly advances our understanding of atmospheric chemistry, indicating that electrical discharges are an important source of oxidation.

https://www.youtube.com/watch?v=wIYr894sLs

Murray wins GEMS Diamond Award



Imani Murray, a 2022 graduate in materials science and engineering, received the 2022 GEMS Diamond Award. The award honors and recognizes a graduating student who shows excellence and balance in academic achievement and volunteer involvement in both University and community activities.

Murray was selected for her leadership across multiple student organizations and other University entities such as serving in the inaugural Justice, Equity, Diversity, and Inclusion Executive Board position in EMS Student Council and as president of the National Society of Black Engineers chapter at Penn State.

Rigby awarded GEMS Alumni Achievement Award

Peter Rigby, a 1979 Penn State graduate in petroleum and natural gas engineering, was awarded the 2021 Graduates of the College of Earth and Mineral Sciences (GEMS) Alumni Achievement Award and accepted the award in September 2021 at the college's Obelisk Society dinner.

The GEMS Alumni Achievement Award is given to recognize outstanding achievement by EMS alumni.

Rigby was selected for innovatively applying his engineering background to financial aspects of the energy sector. Rigby is an author and works with various philanthropic, educational, and humanitarian causes. Before that, he was global head of risk analytics and research at Standard & Poor's.

Rigby was also recognized for service and mentorship to EME students. Rigby designed and launched a unique course on energy crisis leadership. This course gives undergraduate students the opportunity to learn and practice crisis management through case study discussions of actual disasters, ending with a fictitious crisis that plays out in real-time over twenty-four hours.

"The course is one of the most innovative educational opportunities developed for the college in recent years," said Seth Blumsack, professor of energy policy and economics.
https://bit.ly/3n8Zn8l

Peter Rigby (right) accepting the GEMS Alumni Achievement Award from Lee Kump, John Leone Dean in the College of Earth and Mineral Sciences.

Charles L. Hosler Alumni Scholar Medal Recipients

Congratulations to Virginia Ciminelli (left) and Angelique Adams (right) who were awarded Charles L. Hosler Alumni Scholar Medals. The award was established in 1992 to recognize the very highest levels of intellectual achievement or academic service attained by those educated in the college. The award is named in honor of Charles L. Hosler, former dean of the college.

Ciminelli, the 2021 recipient, graduated from Penn State in 1987 with her doctorate in minerals processing and is now a professor in the Department of Metallurgical and Materials Engineering at the Federal University of Minas Gerais in Brazil. Within seven years of her graduation, she was promoted to full professor and was the first woman to receive the rank among the aculty of engineering at her university, an institution with more than a one-hundred-year history.

Adams, the 2022 recipient, is a former Chief Innovation Officer turned author, speaker, and executive coach, and now serves as CEO of Angelique Adams Media Solutions, LLC, a platform dedicated to helping diverse talent excel in their careers. She received her bachelor's degree in chemical engineering in 1997, her master's degree in fuel science in 2002 and her doctorate in fuel science in 2004, all from Penn State.

Shodiya presented with Alumni Achievement Award, named commencement speaker

Titilayo Shodiya, deputy quality manager at the National Institute of Standards and Technology, was one sixteen recipients selected to receive the Alumni Achievement Award from the Penn State Alumni Association. The award recognizes alumni thirty-five years of age and younger for their extraordinary professional accomplishments. She received the award virtually in April 2021. She also was selected to deliver the commencement address for college's spring 2021 graduation ceremony. Shodiya earned her bachelor's degree in materials science and engineering in 2010.

"I'm really happy that I've been able to make Penn State proud with the work that I've been doing," Shodiya said. "I feel immense pride in being selected for the Alumni Achievement Award and to being selected to give the commencement address. I feel like this is just the beginning and I hope that I can keep giving back to Penn State in in any way possible." https://bit.ly/3HNGe5w

Sue Powell Endowment for Transformative Student Experiences created

Sue Powell, now retired director of development and alumni relations, was honored by friends and colleagues with a $50,000 endowment— the Sue Powell Endowment for Transformative Experiences.

Powell stepped down in January 2022 after a thirty-eight-year career of raising funds for the University. The endowment named in her honor is dedicated to supporting EMS students.

"I was hired into EMS by former President Eric Barron, then dean of EMS, who vowed to make us the most student-centered college on campus," Powell said. "I promised I would help accomplish that. It's been my job to keep students at the center of my goals so it's great that this endowment will continue that." https://bit.ly/3Oked6V

Titley named Alumni Fellow

David W. Titley was honored with the Alumni Fellow Award from the Penn State Alumni Association for his long and impactful career of military and public service surrounding his understanding of climate change and risks.

After graduting in 1980, he served as naval officer for thirty-two years and rose to the rank of Rear Admiral. After retiring from the Navy, he served as Deputy Undersecretary of Commerce for Operations, the chief operating officer position at the National Oceanic and Atmospheric Administration. From 2013-19, he served as a professor of practice in meteorology and atmospheric science and professor of international affairs at Penn State, and was founding director for Penn State's Center for Solutions to Weather and Climate Risk. In 2020, he started a new career volunteering for the National Park Service in Grand Teton National Park, Wyoming.

https://bit.ly/3zb7VTa

PennState
College of Earth
and Mineral Sciences

Impact Magazine
510 Eric J. Barron Innovation Hub
123 S. Burrowes Street
State College, PA 16801

Stay connected with EMS

Sign up for e-news at www.ems.psu.edu/e-news

Photo of the Eric J. Barron Innovation Hub on Burrowes Street in State College, new home of the college's administrative offices.

All photos, unless noted, provided by Penn State.

This publication is available in alternative media on request.