2023 Newsletter

The Electricity Dilemma: Hidden Costs and Impacts | Page 41

The University of Texas at Austin
Jackson School of Geosciences

THANK YOU!

From the next generation of geoscientists to the ones who paved the way

WELCOME

Dear Alumni and Friends,

As geoscientists, we study the world in unique ways. Sometimes, we go big: placing sensors deep in subduction zones, using supercomputers to probe massive data sets, collecting sediment cores from deep under the ocean and deploying ice-penetrating radar in Antarctica. Natural systems are not just big. They are also complex, and they stretch the ingenuity of our scientists to tackle important and pressing problems. This year's Jackson School of Geosciences *Newsletter* showcases some amazing "go-big" stories.

Our cover story addresses a question central to energy production choices around the globe: What are the true, cradle-to-grave, economic and environmental costs of using different energy options, including renewables, to produce electricity? When it comes to energy, there is no free lunch (at least no free hot lunch)! Scientists and students at the Bureau of Economic Geology are untangling this complex issue with a project that is remarkable in scope and detail to provide the objective results needed to make sound energy choices in the future.

We report on the huge accomplishment of a successful scientific drilling expedition to recover pressure cores of methane hydrate bearing sediments from the deepwater Gulf of Mexico. Those cores are now here at The University of Texas at Austin for study. Core samples from the expedition were also examined and sampled for everything from chemistry to microbiology. UT was lead institution in this nearly decade-long effort, with Peter Flemings serving as chief scientist. Of special interest: the inclusion of a Jackson School undergraduate student on the rig, participating actively in the science!

Our geophysicists have their sights on Europa—one of Jupiter's icy moons, which may harbor the conditions needed for life. One feature shares their pioneering science and how they are modeling oceans under the ice-encased moon and making plans to peer beneath its shell with radar carried by NASA's Europa Clipper mission, launching October 2024.

Finally, enjoy the feature and a couple of pictures from "way back when" on Scott Tinker, who is stepping down as director of the bureau after 24 years at the helm. What an amazing run! Under Scott's leadership, the bureau has grown into a $30 million per year research juggernaut known across the globe. After stepping down, Scott will continue to work for the bureau in a part-time, remote capacity.

Enjoy the *Newsletter*!

Claudia Mora, Dean

FEATURES

NEWSLETTER HIGHLIGHTS

79 **Mosher Joins Hall of Distinction**
Dean Emeritus Sharon Mosher is inducted into the Jackson School of Geosciences Hall Distinction after more than 40 years of service to the school.

75 **The Professor who Mapped the Earth's Interior**
After a stellar career in seismography, Professor Stephen Grand has retired. His scientific discoveries helped reveal new details about the inner workings of the Earth.

67 **Q&A on New Department Name**
Department Chair Danny Stockli goes in depth on how the newly named Department of Earth and Planetary Sciences reflects the challenges faced by modern geoscientists in a rapidly changing field.

14 **Newly Discovered Layer of Earth**
Scientists have discovered a new layer of partly molten rock under Earth's crust that might help settle a long-standing debate about how tectonic plates move.

IN THIS ISSUE

ON THE COVER: AN ARTISTIC RENDERING OF ELECTRICITY TRANSMISSION TOWERS WITH ORANGE GLOWING WIRES.
PHOTO: ARTUR NICHIPORENKO.

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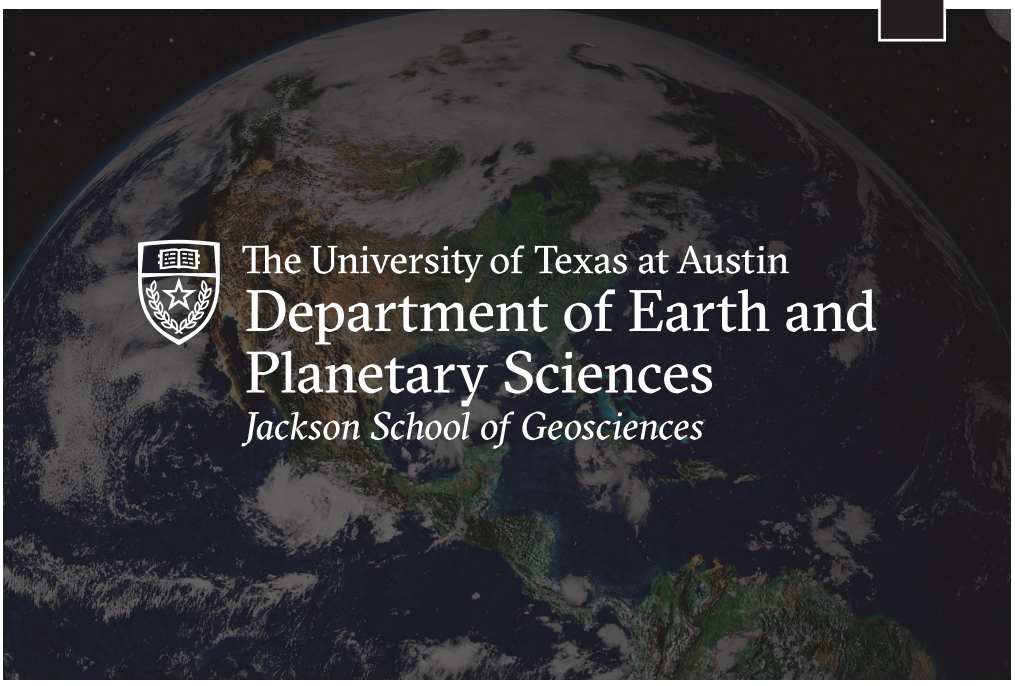
The University of Texas at Austin Jackson School of Geosciences is one of the top research institutions in the world, with a depth and breadth of research that sets it apart. This is made possible by the Jackson School's three world-class units: the Bureau of Economic Geology, the Department of Earth and Planetary Sciences and the University of Texas Institute for Geophysics. Following are some research highlights from the past year.

- *Climate & Environment*
- *Energy Geosciences*
- *Marine Geosciences*
- *Planetary Sciences & Geobiology*
- *Solid Earth & Tectonic Processes*
- *Surface & Hydrologic Processes*
- *Miscellaneous*



New Name Reflects Evolving Field

Miscellaneous

The Department of Geological Sciences has a new name: the Department of Earth and Planetary Sciences.

The new name captures the breadth of research happening in the department and reflects recent changes to the undergraduate curriculum that will help UT geosciences students prepare to take on critical issues facing the planet and society, such as better understanding and mitigating climate change, preparing for natural hazards, and sustainably managing critical Earth resources and water supplies.

"Today's geoscientists do so many things. We're at the confluence of so many different fields," said Danny Stockli, department chair and the Chevron Centennial Professor. "The new name is a more representative vision of what we do, what we teach and, to some extent, what we want to be."

The department is part of the Jackson School of Geosciences and is one of the oldest academic units on campus. Founded in 1888 as the Department of Geology, it expanded rapidly during the Texas oil boom of the early 20th century. It underwent its first name change in 1967 in response to broadening research interests and opportunities, particularly in seismology and geophysics.

Stockli said that the field of geosciences has only continued to grow since then, and now frequently cuts across traditional disciplines to encompass the entire Earth system and other planetary bodies. In the recent past, oil and gas exploration dominated the opportunities available to geosciences students and researchers. Although hydrocarbons remain an important field of study, there are now many different ways to be a geoscientist.

For example, researchers and students in the department are creating climate models to forecast water supply levels, storms and heat waves; investigating an array of energy transition solutions; studying what triggers earthquakes; and exploring how the ingredients for life might reach other worlds.

"It's much more representative of us," Stockli said. "It's a vision of an entire system—the planet, the lithosphere, the hydrosphere, the biosphere, the atmosphere."

The name change also comes as the department is in the midst of updating undergraduate education to better reflect new opportunities in geosciences.

Read more about the new name and curriculum on page 67.

Beaver Fossil Named for Buc-ee's

Planetary Sciences & Geobiology

The most famous beaver in Texas has made it into the fossil record, thanks to scientists at the Jackson School of Geosciences.

The scientists discovered a new species of prehistoric beaver in the school's fossil collections and named it after Buc-ee's, a Texas-based chain of popular travel centers known for its cartoon beaver mascot.

The beaver is called *Anchitheriomys buceei*, or "*A. buceei*" for short.

Steve May, a research associate in the Department of Earth and Planetary Sciences, said that the beaver's Texas connection and a chance encounter with a Buc-ee's billboard inspired the name.

May is the lead author of the paper that describes *A. buceei*, along with another, much smaller, species of fossil beaver. Published in the journal *Palaeontologia Electronica*, the paper provides an overview of beaver occurrences along the Texas Gulf Coast from 15 million to 22 million years ago based on bones and archival records in the Jackson School collections.

While driving down a highway in 2020, May spotted a Buc-ee's billboard that said "This is Beaver Country." The phrase brought to mind the Texas beaver fossils he had been studying.

"I thought, 'Yeah, it is beaver country, and it has been for millions of years,'" May said.

A. buceei lived in Texas about 15 million years ago. Aside from being about 30% larger, it probably resembled modern beavers, according to Matthew Brown, the director of the Jackson School's vertebrate paleontology collections.

The Jackson School collections house *A. buceei* fossils from six Texas sites. But most of what researchers know about the new fossil beaver comes from a unique partial skull from Burkeville, Texas. The fossil is a fusion of bone and a brain cast that was created when sediment naturally seeped into the beaver's brain cavity eons ago, creating a rock replica of its brain as the specimen fossilized.

High-resolution X-ray images of the skull obtained at UT's Computed Tomography Lab brought small anatomical details of the skull into clear view.

The skull was originally collected by a team of Texas paleontologists in 1941. One of them, Curtis Hesse, a museum curator at Texas A&M University, said in notes that he intended to name it a new species. However, Hesse died in 1945 before he could complete his study and publish his findings. Almost 80 years later, May and Brown, with the help of new technology and a better understanding of the beaver fossil record, picked up where Hesse left off.

After hearing about the ancient beaver named after his business, the founder and CEO of Buc-ee's, Arch "Beaver" Aplin III, said that Buc-ee's has a longer history in Texas than he initially thought.

"Buc-ee's was founded in 1982, but we may need to rethink our beginnings," he said.

The study was funded by the Jackson School and the Texas Historical Foundation.

ABOVE: THE FOSSILIZED PARTIAL SKULL OF A. BUCEEI (LEFT) NEXT TO A REPRODUCTION. **PHOTO:** JACKSON SCHOOL.

The Ancient Parrots Next Door

Planetary Sciences & Geobiology

In 2018, while sorting through a bone collection recovered during a New Mexico archaeological dig in the 1950s, John Moretti found a lone ankle bone belonging to a thick-billed parrot

The bone stuck out among the deer and rabbit remains. And it set Moretti, a doctoral student in the Department of Earth and Planetary Sciences, on a journey to figure out how it got there.

"Once I realized that nobody had already described this, I really thought there was a story there," he said.

Moretti discovered that the parrot bone, along with others found in the region, may have been captured locally. This challenged the assumption that all parrot remains found in American Southwest archaeological sites were imports from Mexico. The findings were published in 2022 in *The Wilson Journal of Ornithology*.

Parrot bones are found at southwestern archaeological sites dating back to the 7th or 8th centuries. But the animals usually have been assumed to be imports, according to Moretti.

There's good reason for that. Scarlet macaws—the most commonly found variety—live in rainforest and savannahs, which are not part of the local landscape. And researchers have discovered the remains of ancient parrot breeding facilities in Mexico that point to a thriving parrot trade.

But thick-billed parrots have a different lifestyle and dwell only in mountainous old-growth pine forests. And although they no longer live in the United States due to habitat loss, that wasn't the case a relatively short time ago. As recently as the 1930s, their range stretched from Arizona and New Mexico to northern Mexico, where they live today.

With that in mind, Moretti decided to investigate the connection between pine forests in New Mexico and Arizona and the remains found at archaeological sites. He found that of the 10 sites with positively identified thick-billed parrot remains, all contained buildings made of pine timber. For half the sites, suitable pine forests were within 7 miles of the settlement.

The results suggest that the thick-billed parrots could have been captured locally during timber harvests—and not necessarily imported from afar.

"This paper makes the hypothesis that these [parrots] were not trade items," Moretti said. "They were animals living in this region that were caught and captured and brought home."

The research was funded by the Museum of Texas Tech University, where Moretti earned a master's degree.

ABOVE: A THICK-BILLED PARROT.
PHOTO: U.S. FISH AND WILDLIFE SERVICE.

Upgraded Soil Moisture Map

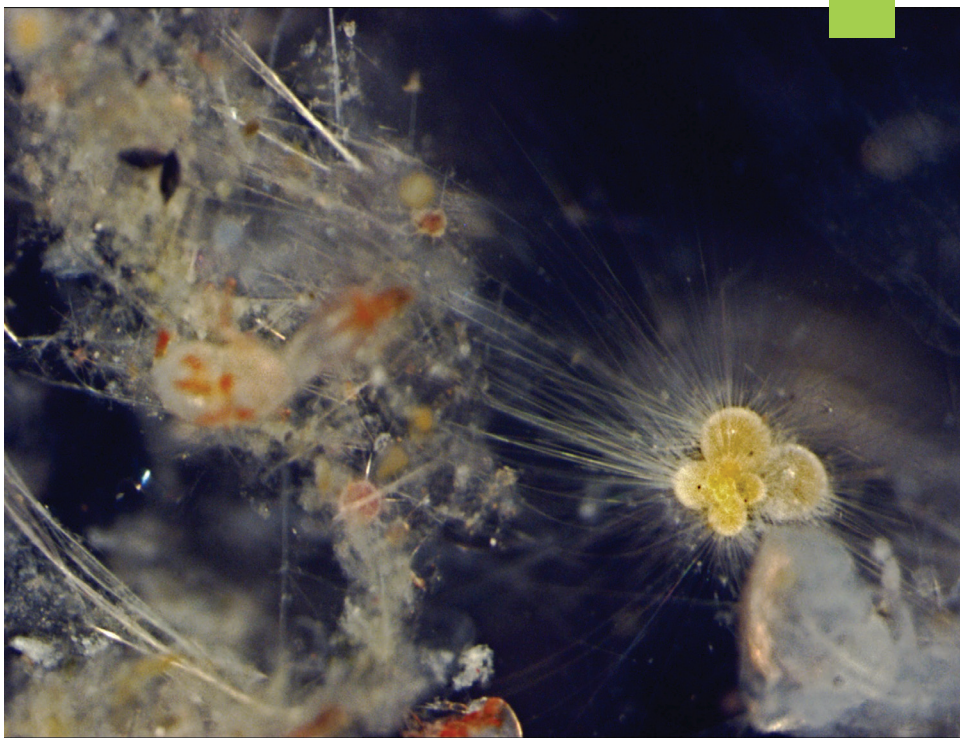
Surface & Hydrologic Processes

During the past year, researchers at the Bureau of Economic Geology have been working to improve the accessibility of soil moisture data collected by a network of monitoring stations known as the Texas Soil Observation Network, or TxSON.

The result is a new web application that includes an interactive map of Texas showing satellite-derived drought information and the latest on-the-ground soil moisture readings from the 58 active TxSON stations.

The stations take precise measurements of precipitation, soil water content and soil temperature every five minutes at multiple depths—generally at 5, 10, 50 and 100 centimeters. Some TxSON stations are outfitted to take additional readings. Eight stations collect weather data, such as wind speed and direction, temperature, relative humidity and solar radiation. Three stations in West Texas measure water quality and flow at natural springs. These readings are also available on the interactive map.

View the map at ***www.beg.utexas.edu/research/programs/txson/map***



Climate Change Could Cause Tropical Plankton Exodus

Climate & Environment

Modern plankton biodiversity in the tropics is a surprisingly recent development and the result of 8 million years of global cooling, according to a study led by researchers at the University of Texas Institute for Geophysics (UTIG).

The finding raises concerns that rapid ocean warming could force plankton, which form the base of marine food chains, to move away from the tropics. This would negatively affect ocean ecosystems, including those of important fish such as tuna and billfish, and coastal communities that depend on them.

The research was published in the journal *Nature*.

Using microfossils to track the history of a group of zooplankton called Foraminifera, the researchers found that the last time Earth was this warm—just before global cooling began 8 million years ago—tropical plankton populations lived in waters more than 2,000 miles from where they are today. The natural cooling of the past 8 million years that allowed the plankton to flourish in the tropics has been reversed by climate change during the past century.

"Earth's current biosphere evolved for ice ages," said lead author Adam Woodhouse, a UTIG postdoctoral fellow. "By suddenly switching to an Earth of 8 million years ago, we're not just killing off a few species, we're changing the entire chemistry of the atmosphere and oceans, and nothing is ready for that."

The findings suggest that plankton species could evacuate the equator and head poleward, researchers said. Other studies of modern plankton have already documented signs of this happening. Researchers fear that the loss of diversity in plankton populations could trigger a cascade of extinctions like those seen in rainforests after logging and fires.

ABOVE: A MICROSCOPE IMAGE OF A SHELLED PLANKTON. PLANKTON POPULATIONS LIKE THIS FLOURISHED IN THE TROPICS DURING PAST GLOBAL COOLING AND MAY VANISH AS THE CLIMATE WARMS.
PHOTO: TRACY AZE.

Cloud Cover Behind Shrinking Daily Temperature Gap

Climate & Environment

An increase in clouds could explain the shrinking difference between the daily high temperature and the daily low in many parts of the world. The gap between the two, known as the diurnal temperature range (DTR), has a significant effect on growing seasons, crop yields, energy consumption and human health.

As part of a collaborative study, researchers at the Department of Earth and Planetary Sciences examined projections of the DTR at the end of the 21st century. They found that the shrinking difference could be due to the increase in clouds blocking incoming-shortwave radiation from the sun during the day.

Climate change is expected to increase the daily maximum temperature and the daily minimum, but the daily maximum temperature will increase at a slower rate due to the influence of clouds. The end result is that the DTR will continue to shrink in many parts of the world, but that the changes will vary depending on a variety of local conditions.

The study, published in the journal *AGU Geophysical Research Letters*, is the first to use high-resolution computer modeling to delve into the issue of the shrinking DTR, particularly how it is related to cloud cover.

"Clouds are one of the big uncertainties in terms of climate projections," said co-author and Professor Dev Niyogi. "When we do this with a very high spatial resolution modeling framework, it allows us to explicitly simulate clouds."

Drilling Deep Into the Earthquake Zone

Marine Geosciences

Scientists who drilled deeper into an undersea earthquake fault than ever before have found that the tectonic stress in Japan's Nankai subduction zone is less than expected, according to a study from researchers at the University of Texas Institute for Geophysics (UTIG) and University of Washington.

Their record-breaking attempt took place in 2018 aboard a Japanese scientific drilling ship, the Chikyu, which drilled two miles into the tectonic plate before the borehole got too unstable to continue, a mile short of the fault.

The findings, published in the journal *Geology*, are a puzzle because the fault produces a great earthquake almost every century and was thought to be building for another big one.

"This is the heart of the subduction zone, right above where the fault is locked, where the expectation was that the system should be storing energy between earthquakes," said UTIG Director Demian Saffer, who co-led the scientific drilling mission. "It changes the way we're thinking about stress in these systems."

Although the Nankai fault has been stuck for decades, the study shows that it is not yet showing major signs of pent-up tectonic stress. According to Saffer, that doesn't alter the long-term outlook for the fault, which last ruptured in 1946 — causing a tsunami that killed thousands — and is expected to do so again during the next 50 years.

The findings will help scientists home in on the link between tectonic forces and the earthquake cycle and potentially lead to better earthquake forecasts, both at Nankai and other megathrust faults such as Cascadia in the Pacific Northwest.

Critical Minerals, Zero-Carbon

Energy Geosciences

Modern technology requires critical minerals, such as lithium, nickel and cobalt. But conventional ways of getting these minerals create significant amounts of carbon dioxide (CO_2) emissions.

A new mining technology being pioneered by researchers at the Bureau of Economic Geology is looking to put those emissions to use by turning the CO_2 into a tool to weaken rock containing critical minerals, reducing the energy needed to mine them. What's more, the ultimate goal is for the emissions to be safely stored in the rock, creating carbon neutral or even carbon negative mining operations as emissions from other operations are piped in and stored.

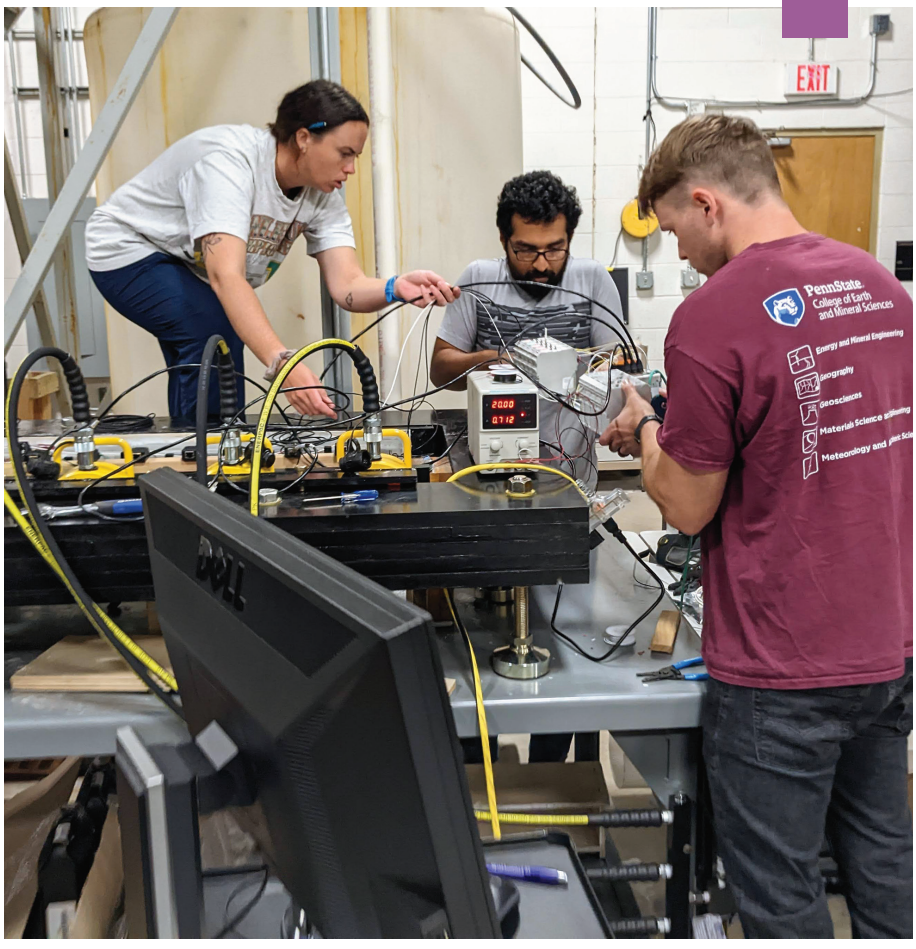
"If you can capture what is produced at the mine, then you can come up with a low-emission operation, which is good, but we want to use the CO_2-reducing properties of ultramafic rocks to help eliminate even more CO_2," said Esti Ukar, a research scientist at the bureau.

Ukar is leading a team of scientists that is working to perfect the mining technology, which is supported by a $5 million grant from the U.S. Department of Energy Advanced Research Projects Agency-Energy.

The method works by taking advantage of chemical reactions between CO_2 and ultramafic rocks, which typically contain critical minerals. When the CO_2 reacts with the rock, it breaks it up, making the minerals easier and less energy intensive to mine. This reaction also incorporates CO_2 into the mineral structure of the ultramafic rock, storing the emissions permanently.

The researchers plan on refining the mining method in the lab for two years before trying a full-scale field test in partnership with Canada Nickel Company. The field test is planned to take place in one of 20 newly discovered ore bodies near the U.S.-Canada border that are forecast to be an important new source of critical minerals in North America. Learn more on page 19.

ABOVE: RARE EARTH OXIDES.
PHOTO: U.S. GEOLOGICAL SURVEY.



Making Quakes in Austin

Solid Earth & Tectonic Processes

After months spent carefully combining black steel plates, delicate sensors and five hydraulic jacks into a device that mimics the sliding of tectonic plates past each other, a team of Jackson School of Geosciences researchers and graduate students successfully triggered an earthquake in the lab on Nov. 7, 2022.

It made an audible snap.

"Today was our first experiment, and—with nothing broken or catching fire—we were able to simulate an earthquake," said Srisharan Shreedharan, who was a postdoctoral fellow at the University of Texas Institute for Geophysics (UTIG) at the time.

The experimental apparatus, known as the "Earthquake Machine," includes a line of four hydraulic jacks that simulate the overlying pressure or load between the plates, which in this case are two blocks of acrylic plastic. A fifth jack piles shear stress onto the system, moving the acrylic 'tectonic plates' past each other, millimeter by millimeter.

Earthquakes occur along the fault line—a quartz powder-filled gap between the acrylic blocks—when the pressure becomes too great. Sensors record each earthquake, including how far the fault slips, the amount of shear stress on the fault, change in volume within the fault during the quake, and seismic radiation.

The earthquakes the machine produces are tiny compared with real-world tremors, but they will give researchers invaluable information about the conditions that cause strong earthquakes and possible precursors warning of an impending quake.

ABOVE: RESEARCHERS SIMULATE AN EARTHQUAKE AT UTIG.
PHOTO: UTIG.

UTIG Joins International Earthquake Effort

Solid Earth & Tectonic Processes

The Jackson School of Geosciences has joined leading scientists on a bold new effort to understand Earth's largest earthquakes and volcanic eruptions.

The plans were detailed in a new report published in November 2022 with the backing of 55 universities.

Demian Saffer, the director of the University of Texas Institute for Geophysics (UTIG) and one of the report's many architects, said the initiative marked the start of a long-term, multinational effort to make hazard forecasting a reality at subduction zones, where the collision of tectonic plates increases the risk of earthquakes and other extreme seismic hazards.

"Our report shapes the future of fundamental science that underpins hazards posed by earthquakes, volcanoes, and landslides, through a major, multi-decadal-scale program to address these grand challenges," he said.

Named Subduction Zones in Four Dimensions (SZ4D), the initiative seeks to install massive arrays of undersea instruments aimed directly at earthquake hotspots in Chile, Alaska and the Pacific Northwest. Data from the instruments will give scientists a never-before-seen picture of Earth's inner workings and help scientists create a new generation of predictive computer models.

In addition to instrument arrays, the report calls for researchers to study the sites' geologic background, conduct laboratory experiments, and build computational models that integrate field observations and laboratory data.

Additional information is available on the SZ4D website at ***www.sz4d.org***.

Breaking Down Broken Foreland Basins

Solid Earth & Tectonic Processes

If you ask a group of geologists to define a broken foreland basin, you're apt to get many different responses. But if you ask why these basins form, there's usually one consensus answer —flat slab subduction.

A study led by the Jackson School of Geosciences is offering a different take. The researchers present a categorical definition for broken foreland basins and suggest that an array of geological mechanisms, not just flat slab subduction, could lead to their formation.

"Many geologists have used broken foreland basins as a definitive marker for a very specific tectonic situation that involves flat slab subduction," said lead author and Professor Brian Horton. "We're starting to recognize that there are multiple potential pathways."

The study was published in *Earth Science Reviews*.

Foreland basins form adjacent to mountain belts, facing the interior of a continent, and fill up over time with eroded sediments deposited across the surrounding lowlands. The basin systems can play a major role in shaping the landscape—influencing climate, waterways and sediment dispersal at the continental scale.

Foreland basins come in two varieties: continuous and broken, with the broken basins hosting deep faults that break up the basin and bring deep basement rock to Earth's surface. But distinguishing between the two basin types has been a fuzzy matter for geoscientists.

The study seeks to remedy that by offering a detailed definition that describes the basin's topographic setting, crustal faults, and sedimentary response to the structural disruption of an otherwise continuous lowland plain. The work also includes a comparative analysis between broken foreland basins and continuous ones.

"It's not just semantics," Horton said. "This approach leads us somewhere new in considering what's driving these systems and their structural and stratigraphic conditions, modern and ancient."

In their synthesis, the researchers caution against viewing flat slab subduction as an exclusive explanation for broken foreland basins, and they argue that there's more than one way to break a basin. They divide the potential drivers into two categories: inherited, preexisting conditions that help promote breakage, and an array of potential triggers that stem from the mountain building process.

Four of the study's co-authors earned doctorates from the Jackson School: Tomas Capaldi, an assistant professor at the University of Nevada, Las Vegas; Chelsea Mackaman-Lofland, an assistant professor at Denison University; Nicholas Perez, an associate professor at Texas A&M University; and Meredith Bush, a high school teacher in Seattle.

The study was funded by the National Science Foundation.

ABOVE: NORTH PLATTE RIVER CANYON INTO THE CASPER ARCH, WYOMING.
BELOW, LEFT TO RIGHT: EOLIAN DUNE FIELD IN THE BERMEJO BROKEN FORELAND BASIN AND SIERRA PIE DE PALO UPLIFT, ARGENTINA; OVERLOOK INTO THE BIGHORN BROKEN FORELAND BASIN, WYOMING; TILTED PERMIAN — JURASSIC STRATA ON A LIMB OF THE CASPER ARCH, WYOMING.
PHOTOS: TOMAS CAPALDI.

Could Comets Stir Life-Giving Stew?

Planetary Sciences & Geobiology

Comet strikes on Jupiter's moon Europa could help transport critical ingredients for life found on the moon's surface to its hidden ocean of liquid water—even if the impacts don't punch completely through the moon's icy shell.

The discovery comes from a study led by researchers at the Jackson School of Geosciences, where researchers developed a computer model to observe what happens after a comet or asteroid strikes the ice shell, which is estimated to be tens of kilometers thick.

The model shows that if an impact can make it at least halfway through the shell, the heated meltwater it generates will sink through the rest of the ice, bringing oxidants—a class of chemicals required for life—from the surface to the ocean.

Scientists have proposed impacts as a means to transport oxidants on Europa, but they assumed the strikes would have to break through the ice. This study suggests that a much larger range of impacts can do the job, said co-author Marc Hesse, a professor in the Department of Earth and Planetary Sciences.

"This increases the probability that you would have the necessary chemical ingredients for life," said Hesse.

The study was published in *Geophysical Research Letters*.

Dino Diversity in Ancient Patagonia

Planetary Sciences & Geobiology

A study led by the Department of Earth and Planetary Sciences is providing a glimpse into dinosaur and bird diversity in Patagonia during the Late Cretaceous, just before nonavian dinosaurs went extinct.

The fossils represent the first record of theropods—a dinosaur group that includes both modern birds and their closest nonavian dinosaur relatives—from the Chilean portion of Patagonia. They include giant megaraptors with large sickle-like claws and modern birds.

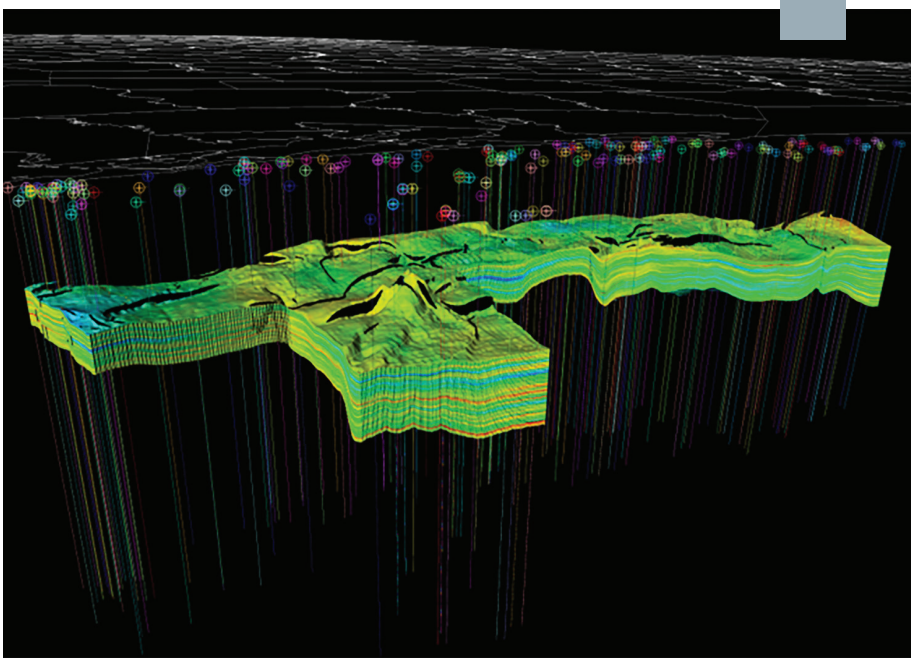
Nonavian theropod dinosaurs were mostly carnivorous, and included the top predators in the food chain. The research shows that in prehistoric Patagonia, these predators included dinosaurs from two groups—megaraptors, which could reach 25 feet in length, and unenlagiines, which ranged from chicken-sized to 10 feet tall and were probably covered in feathers.

"The fauna of Patagonia leading up to the mass extinction was really diverse," said lead author Sarah Davis, who completed this work as part of her doctoral studies with Professor Julia Clarke.

The bird fossils were also from two groups—enantiornithines and ornithurines. Although now extinct, enantiornithines resembled sparrows with beaks lined with teeth and were the most diverse and abundant birds millions of years ago. Ornithurae includes all modern birds living today. The ones living in ancient Patagonia may have resembled a goose or duck, though the fossils are too fragmentary to tell for sure.

The research was funded by the National Science Foundation, the National Agency for Research and Development of Chile, and the Jackson School of Geosciences.

ABOVE: A TIME AVERAGED ARTIST'S INTERPRETATION OF PATAGONIA DURING THE LATE CRETACEOUS, ABOUT 66-78 MILLION YEARS AGO. THE ANIMALS PICTURED INCLUDE NONAVIAN DINOSAURS, BIRDS AND OTHER VERTEBRATES THAT HAVE BEEN DISCOVERED IN THE FOSSIL RECORD OF THE REGION.
PHOTO: MAURICIO ALVAREZ AND GABRIEL DIAZ.



Carbon Capture in Corpus Christi

Energy Geosciences

The Port of Corpus Christi, the country's largest energy port, is working with researchers at the Bureau of Economic Geology on a project to decarbonize by diverting carbon dioxide (CO_2) emissions from its industrial operations to beneath the seafloor of the Gulf of Mexico for permanent storage.

The ultimate goal of the project is to store the emissions deep beneath the seafloor in nearby state-managed waters. Bureau researchers are helping find the best storage locations and determining the technical and economic feasibility of the project.

This feasibility study, which is funded by a $7.36 million grant from the U.S. Department of Energy, will last for two years.

Tip Meckel, a senior research scientist at the bureau, and his team at the Gulf Coast Carbon Center will be using high-resolution marine seismic imaging technology to characterize potential storage sites and collect baseline data that will be used for long-term monitoring if the project proceeds. He said that significant work has already been done in the area by the center that could benefit the project.

"The Gulf of Mexico basin is one of the most studied geologic basins in the world, so we know a tremendous amount about it already," said Meckel, who has been a researcher for over 16 years at the center.

The Port of Corpus Christi is the largest in the nation in terms of total revenue tonnage and is a major exporter of domestically produced energy with more than 200 tenants and customers. As part of a separate project, on which the center is also an adviser, the port is looking at the feasibility of storing the emissions under port-owned property onshore.

Onshore and off, each proposed carbon capture and storage project has a goal of storing at least 50 million metric tons of CO_2 over a 30-year period, which is about the equivalent of the CO_2 emitted by about 11 million average gasoline powered vehicles over a year, according to the U.S. Environmental Protection Agency.

ABOVE: REGIONAL GEOLOGICAL MODEL OF STORAGE COMPLEX FOR THE PORT OF CORPUS CHRISTI CARBON STORAGE STUDY.
PHOTO: TIP MECKEL.

Carbon-Trapping Termites

Climate & Environment

They're a property owner's worst nightmare, but are some termites secretly slowing climate change?

Professor Daniel Breecker and graduate student Morgan Mellum of the Department of Earth and Planetary Sciences, are wiring termite mounds in South Africa with sensors to find out.

Funded by the National Science Foundation, the study is the first stage of a three-year pilot project to gather data on how termites store carbon dioxide (CO_2) underground.

Breecker said the research could be useful for conservationists and policy makers who want to tackle climate change while protecting native species.

"We need to know the rates of CO_2 removal from the atmosphere because the carbon credits associated with it in the mounds may actually be more profitable to local farmers than growing wheat," he said.

Termite mounds are ubiquitous across South Africa. Their presence can shape the landscape, with some mounds persisting for thousands of years. Importantly, most also accumulate calcium carbonate, a chalky substance found in soil, limestone and shells. Breecker and Mellum said that microbes in the mounds might be the reason.

The researchers think that when the termites carry fallen leaves from certain plants back to their mounds, microbes convert the carbon stored in leaves into calcium carbonate, locking it away in the ground. The sensors will tell them how much CO_2 is ending up in the soil, and, importantly, whether it originated from the air originally taken up by the plant leaves or somewhere else.

The CO_2 path from leaves to termites to soil may not be unique to South Africa. Breecker plans to investigate the Sonoran Desert of the southwestern United States, where the saguaro cactus also stores CO_2.

"Half the world's soil is rich in calcium carbonate but there's not much work explaining why," he said. "We need to know what's driving it and how much of it is sequestering atmospheric CO_2."

The termite mound project includes researchers from the Jackson School of Geosciences, Kent State University and Desert Botanical Garden in the U.S., and Stellenbosch University, University of Pretoria and Nelson Mandela University in South Africa.

NASA Endorses Jackson School Lab for Planetary Science

Planetary Sciences & Geobiology

The University of Texas Computed Tomography Facility (UTCT) has been selected by NASA as a facility for planetary science. These facilities have undergone peer review and are supported and endorsed by NASA's Planetary Science Division.

The UTCT is part of the Jackson School of Geosciences. It is equipped with two high-resolution X-ray computed tomography scanners that can image specimens inside and out with a resolution down to 1 micrometer per voxel (3D equivalent of a pixel).

The facility has a long record of advancing planetary science by scanning samples from space, including meteorites left over from the formation of the solar system and lunar samples brought back to Earth by Apollo astronauts.

Research Associate Romy Hanna is the principal investigator on the NASA grant supporting the lab and point person for planetary research projects.

To view a full list of NASA facilities, visit: ***science.nasa.gov/researchers/planetary-science-enabling-facilities.***

UTIG: 50 Years of Exploration and Discovery

Miscellaneous

The University of Texas Institute for Geophysics (UTIG) celebrated 50 years as a world leader in geophysical research at a symposium in November 2022. The event looked back on UTIG's part in historic discoveries and highlighted ongoing projects and research topics.

"Fifty years is a significant milestone," said UTIG Director Demian Saffer. "It's a time to reflect on the scientific contributions."

The institute has played important roles in historic discoveries, including those in the areas of plate tectonics, sea level rise, earthquakes, planetary exploration, and the extinction of nonavian dinosaurs.

Founded in 1972 by renowned geophysicist Maurice Ewing, UTIG was originally situated in Galveston, Texas. The institute moved to Austin in 1982 under director Art Maxwell, where it became part of the Jackson School of Geosciences in 2001.

The institute's first major assignments included support missions for the Unites States' fledgling scientific ocean drilling program and analysis of instrument data from NASA's Apollo moon landings. According to UTIG Senior Research Scientist Jamie Austin, the ocean survey missions set UTIG apart as a leader in expeditionary field research.

"We've gotten more co-chief scientists that have run expeditions around the world in the drilling program than anybody else," Austin said.

Today, the institute's researchers lead field studies at sites across the world, from the South Pole to the Highland Lakes of Central Texas. They are also working with NASA to send a UTIG-developed radar system to look for life on the ice world of Europa.

Away from the field, the institute has helped bring computational geosciences to the mainstream. Today, UTIG researchers use supercomputers to make climate predictions and breakthroughs in earthquake forecasting.

To learn more and see photos from the event, visit ***ig.utexas.edu/50-years.***

ABOVE: GRADUATE STUDENT SHUAI YAN (FOURTH FROM RIGHT) WITH FELLOW SCIENTISTS IN EAST ANTARCTICA.
PHOTO: SHUAI YAN.

Mineral Origins of Golden Fossils

Planetary Sciences & Geobiology

All that glitters is not gold, or even fool's gold in the case of fossils.

A recent study by scientists at the Jackson School of Geosciences and their collaborators found that many of the fossils from Germany's Posidonia shale do not—as previously thought—get their gleam from pyrite, commonly known as fool's gold. Instead, the golden hue is from a mix of minerals that hints at the conditions in which the fossils formed.

The findings, published in *Earth Science Reviews*, provide insight into how these well-preserved specimens of sea life from the Early Jurassic formed in the first place, and the role of oxygen in their formation.

When the researchers used scanning electron microscopes to study the fossils' chemical composition, they found that the fossils were mainly composed of phosphate minerals and very little pyrite. However, the surrounding black shale rock was dotted with microscopic clusters of pyrite crystals, called framboids.

The fact that the pyrite and phosphate are found in different places on the specimens suggests that although an anoxic (without oxygen) seafloor sets the stage for fossilization—keeping decay and scavengers at bay—it took a pulse of oxygen to drive the chemical reactions needed for fossilization.

"[Anoxia] helps with making the environment conducive to faster fossilization, which leads to the preservation, but it's oxygenation that's enhancing preservation," said co-author Sinjini Sinha, a doctoral student at the Jackson School.

The research was funded by Cornell College and the National Science Foundation. The Posidonia fossil specimens used in this study are now part of the collections at the Jackson School's Non-Vertebrate Paleontology Laboratory.

ABOVE: AMMONITE FOSSIL FROM THE OHMDEN QUARRY, POSIDONIA SHALE LAGERSTATTE. **PHOTO:** SINJINI SINHA.

Seamount Collisions Produce Slower Earthquakes

Marine Geosciences

A seismic survey led by the University of Texas Institute for Geophysics (UTIG) has found that sinking seamounts leave behind a trail of soft sediments as they're pulled into subduction zones. These sediments may help weaken earthquakes by relieving tectonic pressure. UTIG Senior Research Scientist Nathan Bangs led the research, which was published in June 2023 in the journal *Nature Geoscience*. The findings may help scientists improve earthquake models and unravel the mechanisms that drive earthquakes.

In 2018, Bangs led an ocean seismic survey of a subduction zone off the coast of New Zealand. The resulting images showed seamounts—mountains and volcanoes on the seafloor—colliding with the subduction zone and the sediment trail they leave behind. The researchers think the sediment from this trail may help create conditions in the crust suitable for harmless slow slip earthquakes rather than violent tremors—at least in this part of the New Zealand subduction zone, where the crust holds softer, wetter rocks.

The research and seismic survey were funded by the National Science Foundation and similar scientific agencies in New Zealand, the United Kingdom and Japan.

Measuring and Managing the World's Water

Surface & Hydrologic Processes

A review study led by the Bureau of Economic Geology and published in *Nature Reviews Earth & Environment* provides a look at the world's freshwater resources and potential strategies for managing them.

Led by Bridget Scanlon, a senior research scientist at the bureau, the study draws on data from satellites, climate models, monitoring networks and almost 200 scientific papers to analyze Earth's water supply and how it's changing over time.

The study cites numerous examples of human activity affecting this flux between surface water and groundwater supplies. For example, surface water irrigation recharged aquifers in the early to mid-1900s in the northwestern U.S.'s Columbia Plateau and Snake River Plain, while global models show that groundwater pumping has greatly reduced the volume of water going to streams, with 15%-21% of global watersheds at risk because of the reduced flows.

The study emphasizes the inherent connection between surface water and groundwater supplies. According to the researchers, future water resilience depends on recognizing that surface water and groundwater behave as a single resource and developing water management solutions that take both water supplies into account.

The study also describes both natural and engineered approaches to water management that can help increase water supplies, reduce demand, store water and transport it. According to Scanlon, one of the best ways to adapt to increasing climate extremes is storing water during wet times and drawing on it in times of drought.

"We have droughts and we have floods," she said. "We are trying to manage those extremes, and a way to do that is to store water."

Bureau Partners With Island Nation of Timor-Leste on Energy Project

Energy Geosciences

In January 2023, a team of researchers from the Bureau of Economic Geology travelled to the small island nation of Timor-Leste to discuss how the bureau can assist with energy development.

The researchers were invited by the national oil and gas company of the nation, TIMOR GAP. The company is seeking the bureau's assistance in characterizing, and one day developing, the nation's significant natural gas reserves and in exploring the potential for other technologies, such as storing carbon dioxide emissions and hydrogen in depleted reservoirs.

The travel team included bureau researchers Robin Dommisse, Dallas Dunlap, Jay Kipper, Toti Larson, and Hongliu Zeng, as well as Mojdeh Delshad from The University of Texas at Austin Hildebrand Department of Petroleum and Geosystems Engineering.

During the trip, the bureau team met with the nation's energy minister and briefed U.S. Embassy staffers on the project.

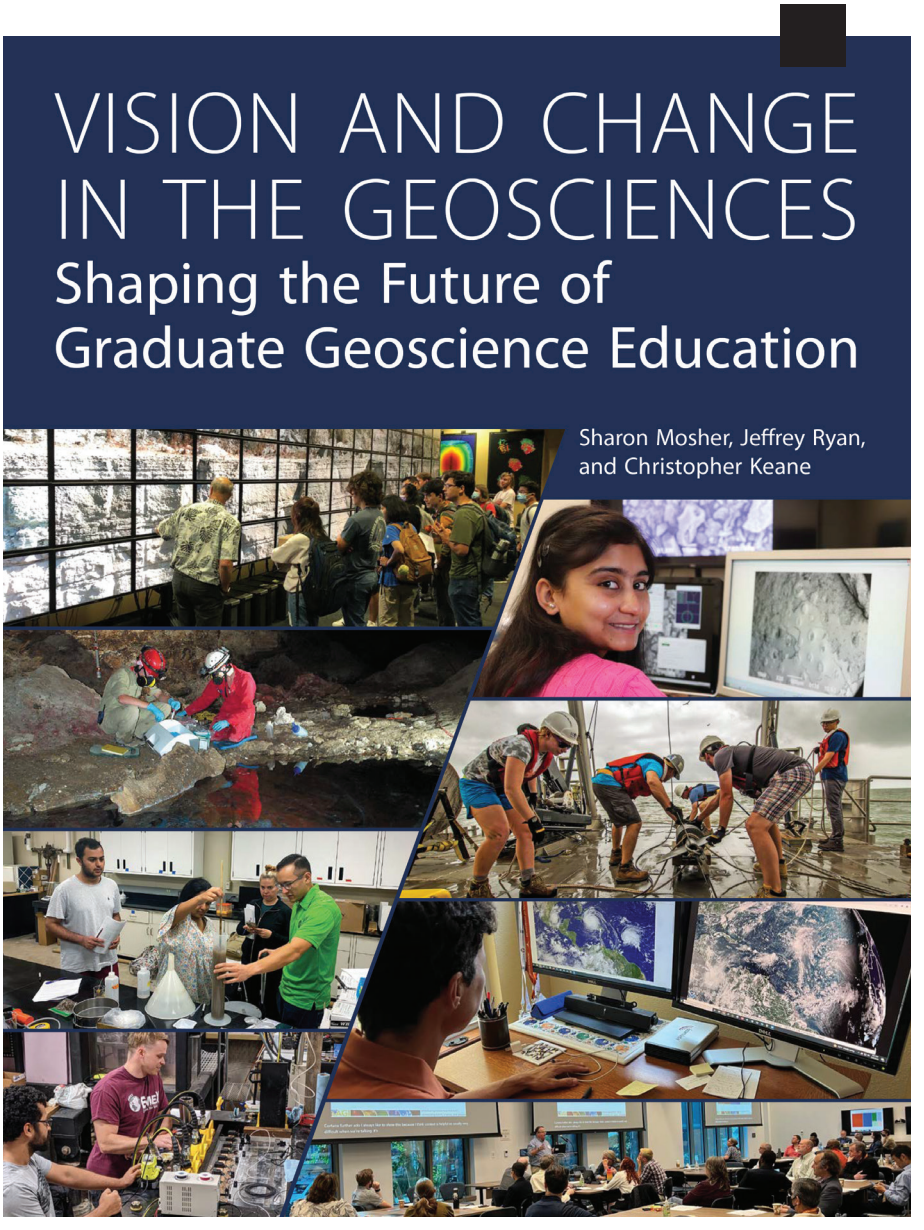
"The people we met were wonderful—caring, thoughtful and enthusiastic to work on this project," said Dunlap, the project's manager. "Our team established a real bond with them, and we are all deeply invested in the success of this project. Having the benefit of revenue from gas production could be a game changer for Timor-Leste's economy and for the future prosperity of its people."

Timor-Leste is in the southern Pacific Ocean, north of Australia, and has a population of about 1.1 million people. The nation is predominantly agrarian, but is looking to expand its infrastructure and modernize its economy as its population grows.

The bureau will use state-of-the-art geological, geophysical, and petroleum engineering technologies to conduct a comprehensive evaluation of the country's Greater Sunrise Field Complex, which contains two undeveloped gas and condensate fields.

The studies will be done in close collaboration with TIMOR GAP engineers and geoscientists to allow for seamless knowledge transfer. Three to six TIMOR GAP scientists will travel to the bureau soon for several months of work on the integrated project, giving them a hands-on perspective on research techniques and technology as well as providing them an opportunity to return home with new research and leadership skills.

ABOVE: THE BUREAU'S ROBIN DOMMISSE (STANDING) SHOWS VISUALIZATION TECHNOLOGY TO PROJECT COLLABORATORS.
PHOTO: BUREAU OF ECONOMIC GEOLOGY.



Shaping the Future of Graduate Geosciences Education

Miscellaneous

Geoscientists play a central role in addressing global and societal challenges, ranging from sustainable energy, mineral and water resources, severe weather and changing climate, and ocean health and events to geohazard and environmental impacts.

A new report—spearheaded by the Jackson School of Geosciences, sponsored by the National Science Foundation and published by the American Geoscience Institute in September 2023—provides a roadmap for change for those interested in shaping the future of graduate geoscience education to better tackle these challenges.

"Across the geoscience disciplines and subdisciplines, there are universal skills that are needed for success regardless of career choice," said Sharon Mosher, Jackson School dean emeritus. "The geoscience community has come together to assess these skills and how changes in graduate education and collaboration with external stakeholders can best prepare our students for a broad and expanding spectrum of geoscience careers available now and in the future."

This report comes after five years of discussion, input, and feedback from more than 300 members of the geoscience community in academia, industry, government, NGOs and professional services. It builds on the "Vision and Change in the Geosciences: The Future of Undergraduate Geoscience Education" ***(www.americangeosciences.org/change)***, published in 2021.

Mosher is the report's principal investigator and driving force behind the project. The seven-section report outlines why change is necessary for the long-term growth and future of graduate geoscience education and the geoscience profession and identifies strategies for transformative change.

A full text of the report and a free PDF version are available at: ***graduate.americangeosciences.org.*** Print copies can be purchased through Amazon.

LEFT: THE COVER OF VISION AND CHANGE IN THE GEOSCIENCES.
PHOTO: SHARON MOSHER.

When Air Pollution and Climate Change Mix

Climate & Environment

The effects of air pollution on human health, economies, and agriculture differ drastically depending on where on the planet the pollutants are emitted, according to a study that could incentivize certain countries to cut climate-changing emissions.

Led by the Jackson School of Geosciences and the University of California San Diego, the study, published in *Science Advances*, is the first to simulate how aerosol pollution affects both climate and air quality for locations around the globe.

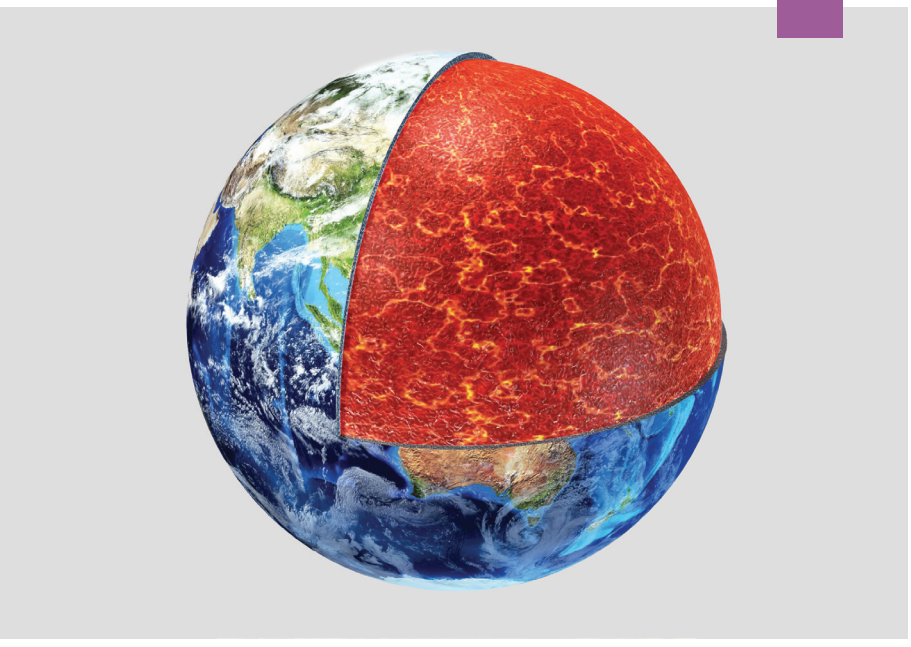
Aerosols are tiny solid particles and liquid droplets that contribute to smog and are emitted from industrial factories, power plants and vehicle tailpipes. They affect human health and agricultural and economic productivity in unique global patterns different from those of carbon dioxide (CO_2) emissions, which are the focus of efforts to mitigate climate change.

Although CO_2 and aerosols are often emitted at the same time during the combustion of fuel, the two substances behave differently in Earth's atmosphere, said co-lead author Geeta Persad, an assistant professor in the Department of Earth and Planetary Sciences.

"Carbon dioxide has the same impact on climate no matter who emits it," said Persad. "But for these aerosol pollutants, they tend to stay concentrated near where they're emitted, so the effect that they have on the climate system is very patchy and very dependent on where they're coming from."

The researchers found that, depending on where they are emitted, aerosols can worsen the social costs of carbon—an estimate of the economic cost that greenhouse gases have on society—by as much as 66%. The scientists looked at eight key regions: Brazil, China, East Africa, Western Europe, India, Indonesia, United States and South Africa.

The outcome paints a varied and complicated picture. Emissions from some regions produce climate and air quality effects that range from two to more than 10 times as strong as others. Sometimes the social costs affect neighboring regions more than the region that produced the aerosol emissions. For example, emissions generated in Europe result in four times as many infant deaths outside Europe as within.



Newly Discovered Layer of Earth

Solid Earth & Tectonic Processes

Scientists at the Jackson School of Geosciences have discovered a new layer of partly molten rock under Earth's crust that might help settle a long-standing debate about how tectonic plates move.

Researchers had previously identified patches of melt at a similar depth. But a new study published in *Nature Geoscience* has revealed for the first time the layer's global extent and its part in plate tectonics.

The molten layer is about 100 miles from the surface and is part of the asthenosphere, which sits under Earth's tectonic plates in the upper mantle. The asthenosphere is important for plate tectonics because it forms a relatively soft boundary that lets tectonic plates move through the mantle.

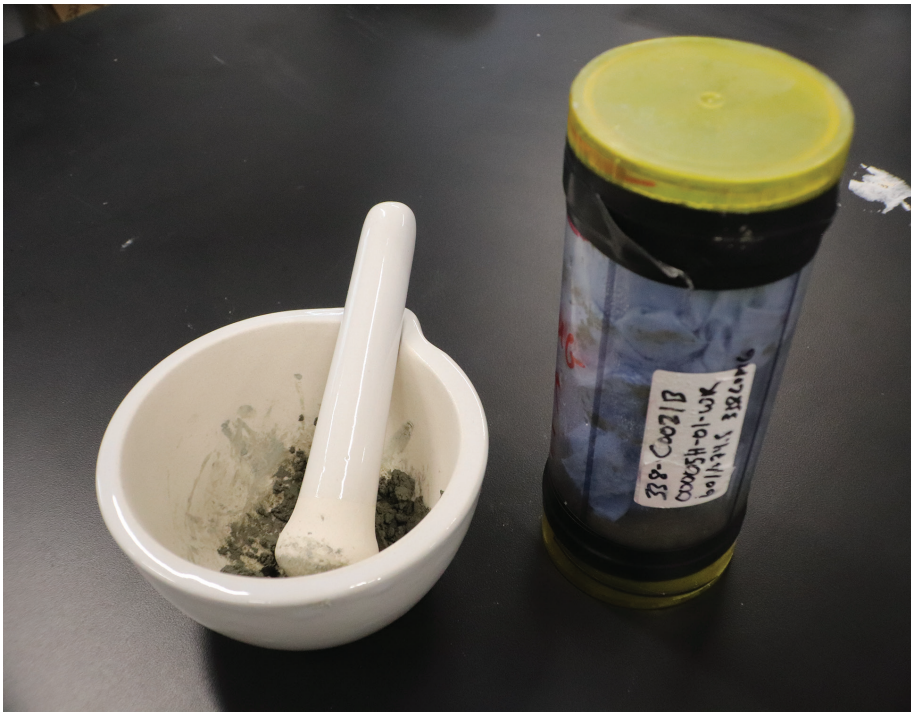
The reasons it is soft, however, are not well understood. Scientists previously thought that molten rocks might be a factor. But this study shows that melt, in fact, does not appear to notably influence the flow of mantle rocks.

"When we think about something melting, we intuitively think that the melt must play a big role in the material's viscosity," said postdoctoral fellow Junlin Hua, who led the research. "But what we found is that even where the melt fraction is quite high, its effect on mantle flow is very minor."

The idea to look for a new layer in Earth's interior came to Hua while he was studying seismic images of the mantle beneath Turkey during his doctoral research at Brown University. Intrigued by signs of partly molten rock under the crust, Hua compiled similar images from other seismic stations until he had a global map of the asthenosphere. What he and others had taken to be an anomaly was commonplace around the world, appearing on seismic readings wherever the asthenosphere was hottest. The next surprise came when he compared his melt map with seismic measurements of tectonic movement and found no correlation, despite the molten layer covering almost half of Earth.

The research was funded by the National Science Foundation. Collaborating institutions included the UT Oden Institute for Computational Engineering and Sciences and Cornell University.

ABOVE: A FIGURE OF THE EARTH WITH THE UPPER MANTLE REVEALED.
PHOTO: LEONELLO CALVETTI/DREAMSTIME.



Fault Healing

Solid Earth & Tectonic Processes

Scientists at the University of Texas Institute for Geophysics (UTIG) have found that slow healing faults are more likely to move harmlessly, while those that heal quickly are more likely to stick until they break in a large, damaging earthquake.

The discovery could be key to understanding when, and how violently, faults move. That alone won't allow scientists to predict when the next big one will strike—the forces behind large earthquakes are too complex—but it does help researchers investigate the potential for large, damaging earthquakes in different places.

"The same physics and logic should apply to all different kinds of faults around the world," said the study's co-lead author and UTIG Director Demian Saffer. "With the right samples and field observations we can now start to make testable predictions about how big and how often large seismic slip events might occur on other major faults, like Cascadia in the Pacific Northwest."

The results were published in the journal *Science*.

To make the discovery, researchers devised a test that combined rocks from a well-studied fault off the coast of New Zealand and a computer model to successfully calculate that a harmless kind of "slow motion" earthquake would happen every few years. The results were nearly an exact match with observations from the New Zealand fault.

The researchers think the clay-rich rocks within the fault, which are very slow to heal, could be regulating earthquakes by allowing plates to slip quietly past each other, which limits the buildup of stress.

"This doesn't get us any closer to actually predicting earthquakes, but it does tell us whether a fault is likely to slip silently with no earthquakes, or have large ground-shaking earthquakes," said study co-lead author Srisharan Shreedharan, an affiliate researcher at UTIG and assistant professor at Utah State University.

The research was funded by UTIG, the International Ocean Discovery Program, and New Zealand's GNS Science.

ABOVE: MATERIAL DRILLED FROM AN EARTHQUAKE FAULT IN JAPAN BEING PREPARED FOR LAB TESTING.
PHOTO: UTIG.

Salt Could Play Key Role in Energy Transition

Energy Geosciences

A common ingredient—salt—could have a big role to play in the energy transition to lower-carbon energy sources, according to a study led by the Bureau of Economic Geology.

The study describes how large underground salt deposits could serve as hydrogen holding tanks, conduct heat to geothermal plants, and influence carbon dioxide (CO_2) storage. It also highlights how industries with existing salt expertise, such as solution mining, salt mining, and oil and gas exploration, could help.

"We see potential in applying knowledge and data gained from many decades of research, hydrocarbon exploration, and mining in salt basins to energy transition technologies," said lead author Oliver Duffy, a research scientist at the bureau. The study was published in the journal *Tektonika*.

Salt has an influential role in shaping Earth's subsurface layers. It is easily squeezed by geologic forces into complex and massive deposits, with some subsurface salt structures taller than Mount Everest. These structures and their surrounding geology offer a number of opportunities for energy development and emissions management, said study co-author Lorena Moscardelli, director of the bureau's State of Texas Advanced Resource Recovery (STARR) program, which funded the research.

"The co-location of surface infrastructure, renewable energy potential, favorable subsurface conditions and proximity to markets is key to plan for subsurface hydrogen storage," she said. "STARR is currently engaged with emerging energy opportunities in West Texas that involve hydrogen and carbon capture, utilization and storage potential for the region."

According to the paper, salt could help grow hydrogen power by serving as a holding pen for hydrogen gas.

Salt domes are proven containers for hydrogen used by oil refineries and the petrochemical industry. But hydrogen bound for energy production faces different conditions, such as increased storage volumes and more frequent input and output of the gas from storage caverns. The study calls for more research on hydrogen storage in salt formations under these conditions.

Salt caverns are not a good option for CO_2 storage for myriad reasons—from economic, to long-term leakage risks, to the sheer magnitude of CO_2 that needs to be stored. But the rock formations surrounding the salt domes are a different story. They are made of porous rock that can safely accommodate large volumes of CO_2, which could allow for co-locating hydrogen production from natural gas and CO_2 storage. The Texas Gulf Coast is particularly well suited for this type of combined production and storage, according to the researchers.

The study also touches on how salt can aid in the adoption of next-generation geothermal technology. Co-authors include current and former bureau researchers Michael Hudec, Frank Peel, Gillian Apps, Alex Bump, Tim Dooley, Naiara Fernandez, Shuvajit Bhattacharya, Ken Wisian and Mark Shuster.

Probing Ice Sheets on Earth and Europa

Planetary Sciences & Geobiology

A radar technique developed by scientists at the University of Texas Institute for Geophysics (UTIG) could be used to investigate melting glaciers on Earth as well as detect potentially habitable environments on Jupiter's moon Europa. The research was published May 2023 in the journal *The Cryosphere*.

The near-surface layers of ice sheets are difficult to study with traditional airborne or satellite ice-penetrating radar, but this new technique allows them to image hidden features within the upper few feet of ice sheets.

The researchers tested the technique by flying radar surveys over the Devon Ice Cap in the Canadian Arctic, mapping a slab-like layer of impermeable ice near the surface. The analysis suggested that the ice layer redirects surface melt from the ice cap's snow-packed surface into water channels downhill.

According to Kristian Chan, a graduate student at the Jackson School of Geosciences who devised the technique, the findings about the ice slab layer could help scientists predict the future of the ice cap and its contribution to sea level rise. Additionally, Chan said the technique could be applied to ice-covered ocean worlds like Jupiter's moon Europa.

In fact, Chan is part of a UTIG group that has developed an ice-penetrating radar instrument called REASON, which will launch aboard NASA's Europa Clipper in 2024. The instrument will probe Jupiter's icy moon Europa, looking for clues about whether its ocean or ice shell could harbor life. Chan's technique allows REASON to target the upper few feet of Europa's ice shell where frozen brines or cryovolcanic remnants might be found. Those are of interest to scientists because they are good spots to look for signs of habitable environments that are near enough to the surface to be accessed by future landers.

The research was supported by the NASA Texas Space Grant Consortium at UTIG and the G. Unger Vetlesen Foundation. See more on page 21.

ABOVE: A HELICOPTER EQUIPPED WITH AN ICE-PENETRATING RADAR REFUELS ON THE ICE AT THE ARCTIC'S DEVON ISLAND.
PHOTO: COREY SKENDER.

Jackson School of Geosciences researchers made science news headlines and served as expert sources for news stories across the state and the world. Check out a few of the highlights.

KXAN, Salt Could Be Key Ingredient for Clean Energy Transition, UT Researchers Say

Featuring Lorena Moscardelli, Director of the State of Texas Advanced Resource Recovery Program; Oliver Duffy, Research scientist; and Ander Martinez-Doñate, Postdoctoral Researcher

CNN

Hidden Molten Rock Layer Found Beneath Earth's Tectonic Plates

"When we think about something melting, we intuitively think that the melt must play a big role in the material's viscosity, but what we found is that even where the melt fraction is quite high, its effect on mantle flow is very minor."

Junlin Hua, Postdoctoral Researcher
Department of Earth and Planetary Sciences
Feb. 2, 2023

The Daily Texan

UT Researcher Launches Water Resources Podcast to Discuss Global Water Issues

"People may not have time to read (scientific) papers, so I thought this was a nice way to communicate what people are doing (to tackle) different critical issues."

Bridget Scanlon, Senior Research Scientist
Bureau of Economic Geology
April 16, 2023

Texas Monthly

UT Scientists Discovered a Beaver Fossil and Named It After Buc-ee's

"We have somewhere in the neighborhood of over a million fossils in this building...We've got paleontologists coming here like kids in a candy store."

Matthew Brown, Director of the Vertebrate Paleontology Laboratory
March 28, 2023

KXAN, Researchers in Austin Have Found That Microplastics Are Collecting Everywhere in Central Texas' Waterways

Featuring Cornel Olariu, Research Scientist and Lecturer

Midland Reporter-Telegram

Investigator: Number of Permian Quakes Trend Downward

"Operators and regulators are adapting, using data and trends successfully."

Peter Hennings, Principal Investigator for the Center for Integrated Seismicity Research
Bureau of Economic Geology
April 5, 2023

THE NEW YORKER, Journey to the Doomsday Glacier

The New Yorker's Nov. 28, 2022, issue featured a dispatch on geophysics research in Antarctica from David W. Brown, a writer and field-research associate sponsored by the University of Texas Institute for Geophysics. The article features Jamin Greenbaum, who was then a UTIG research associate and a scientist at the Scripps Institution of Oceanography.

Houston Public Media

Benefits, Feasibility of Geothermal Energy in Texas Examined in New Study

"The technology that is emerging now, and we're in the prototype stage on, would allow us to drill, for instance, five kilometers—about three miles deep—under Houston, and extract the heat and generate power."

Ken Wisian, Associate Director, Environmental Division
Bureau of Economic Geology
Jan. 30, 2023

New Scientist

Shards of Pure Ice Might Snow Upwards Beneath the Ice Shell of Europa

"At the bottom of the ice shelf it could be pretty mushy...We have actually seen protists in these environments on Earth, which hints that these might be good environments to look for life—assuming we can get to them."

Natalie Wolfenbarger, Graduate Research Assistant
University of Texas Institute for Geophysics
Aug. 19, 2022

NPR

Study Shows the Potential Consequences of Climate Change for the Ocean Food Web

"So you just kind of have pages of the book of life. The more sediment you dig up, the more kind of pages you're opening as you go down."

Adam Woodhouse, Postdoctoral Researcher
University of Texas Institute for Geophysics
March 8, 2023

CURIOSITY STREAM, Earthquake Research at the University of Texas Institute for Geophysics Is the Focus of a Documentary Called 'Forecasting the Big One'

The film features UTIG director Demian Saffer and Bureau of Economic Geology researcher Chas Bolton, as well as graduate students Kaitlin Schaible and Peter Miller (pictured here during filming).

MORE JACKSON SCHOOL NEWS
www.jsg.utexas.edu/news
or scan below

CARBON-FREE MINING REVOLUTION

Q&A

By Anton Caputo

Esti Ukar is a research scientist at the Jackson School of Geosciences Bureau of Economic Geology. She earned a Bachelor of Science in geology at Euskal Herriko Unibertsitatea/ Universidad del País Vasco in Spain in 2003 and a doctorate in geological sciences at the Jackson School in 2010.

Ukar is leading a project to develop technology for mining critical minerals — mineral resources that are essential to the economy and whose supply may be disrupted — more efficiently and without adding any carbon dioxide to the atmosphere. The three-year, $5 million project is part of the Department of Energy's (DOE) Mining Innovations for Negative Emissions Resource Recovery (MINER) program, which aims to develop market-ready technologies that will increase domestic supplies of critical elements required for clean energy technology.

LEFT: ESTI UKAR.
PHOTO: ANDRAS FALL.

Tell us a little bit about the project. Why is it important to decarbonize mining?

As you probably know, there is an urgent drive to develop low-carbon emission energy technologies and sources of energy all over the world. A major element of this effort is using electric vehicles instead of vehicles that burn gasoline. But the batteries that power these vehicles require lots of lithium, nickel, cobalt and other elements that are in low concentrations in the Earth's crust and are often referred to as "critical minerals." Mining these takes a tremendous amount of energy and produces significant CO_2 emissions and other negative environmental impacts, which is exactly what we're trying to avoid. That's what we're trying to address.

Are you trying to make these mining operations carbon free or carbon neutral?

Carbon neutral or better yet, carbon negative. If you are able to capture and store all the CO_2 produced during the mining operations, that makes it carbon neutral. We want to go beyond that and capture even more carbon, making the operation carbon negative. That means in addition to storing the CO_2 from the mining operation, we would be able to take CO_2 from other industrial sources and store it underground too.

Can you explain how the CO_2 storage process works?

Storing CO_2 underground so it is not released into the atmosphere is an issue that we have been working on at the Bureau of Economic Geology for decades. In this project, we plan to inject a solution of water and CO_2 into ultramafic rock containing critical minerals. This solution helps partially replace the ultramafic rock with softer carbonate and pre-fracture the rock. Breaking and weakening the rock's structure is expected to reduce energy requirements for crushing and grinding the critical mineral ore. At the same time, the CO_2 in the solution reacts with magnesium, iron and calcium that is also in the rock. This reaction leads to the CO_2 being incorporated into the rock's mineral structure—permanently storing it. In addition to offsetting the mine's emissions, the CO_2 storage process could also be eligible for federal CO_2 credits, which could help make mining critical minerals more affordable and lead to greater production throughout North America.

Where do you plan on doing this project?

We will spend the first two years perfecting the process in the lab before taking it to the field. We particularly want to work on finding ways to make the reaction that stores CO_2 in ultramafic rock faster. Instead of geologic timescales, we need to make the reactions occur within weeks to months for the process to be economically viable for mining. The research will also involve computer modeling and determining the best CO_2-H_2O cocktail, pressure-temperature conditions and rates of injection.

After perfecting the method in the lab, we will conduct a full-scale field test in partnership with Canada Nickel Company in one of 20 newly discovered ore bodies near the U.S.-Canada border thought to be an important new source of critical minerals in North America.

Has this been done before?

Not in ultramafic rock like we are proposing to do, mostly because ultramafic rocks have low permeability that make it difficult to get the fluids in. But we believe we have found a way to make it work. There is a project in Iceland called CarbFix that has been storing carbon in basalt for years. It's a different type of mafic rock, and there is no mining associated, but the method is similar. In fact, Dr. Sandra Ósk Snæbjörnsdóttir, who is the head of CO_2 mineral storage for CarbFix, is collaborating with us on this project.

> "If you are able to capture and store all the CO_2 produced during the mining operations, that makes it carbon neutral. We want to go beyond that and capture even more carbon, making the operation carbon negative."
>
> *-Esti Ukar*

You are leading a large multidisciplinary team in this project. Can you tell us who is involved?

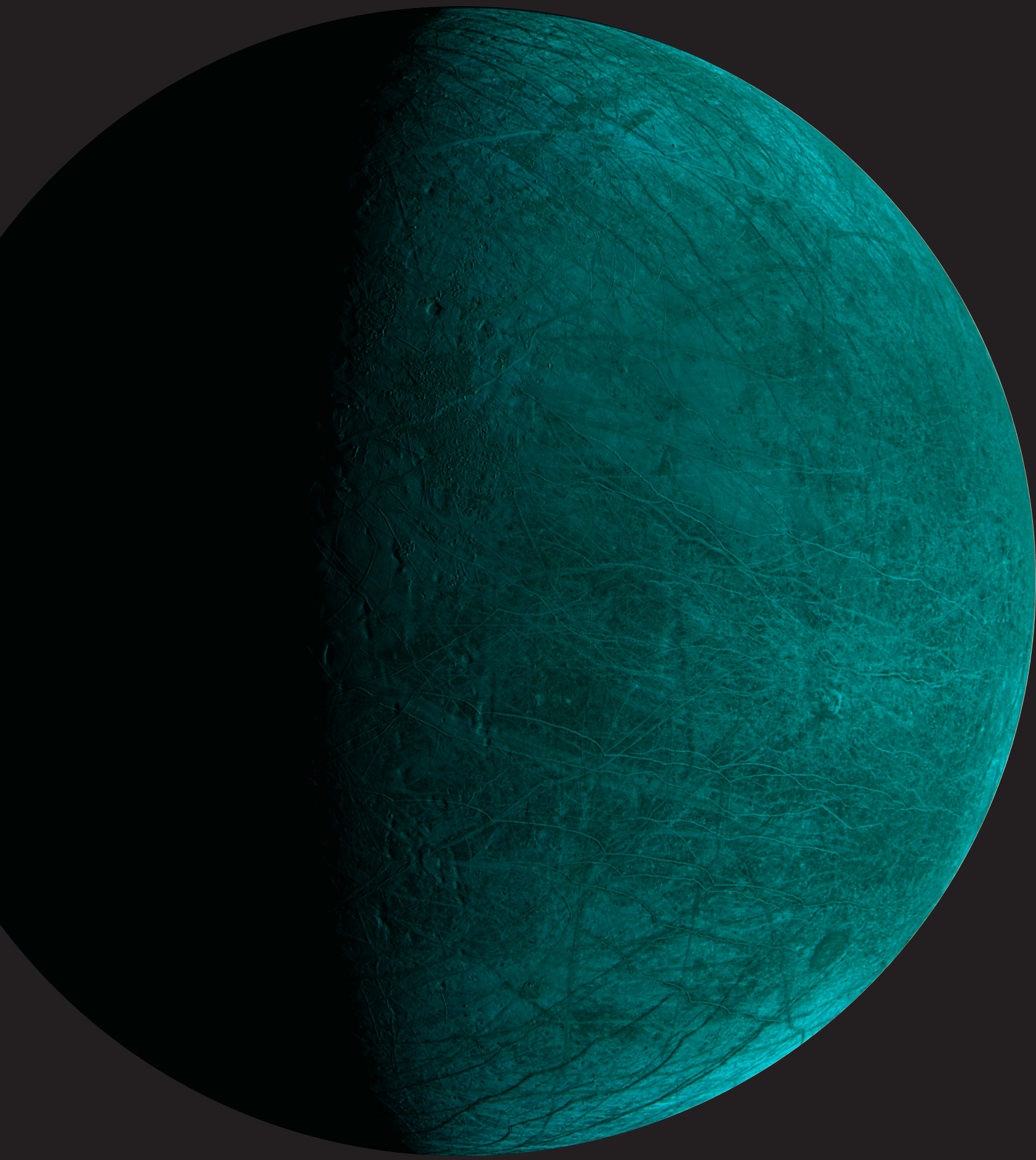
We have several areas of the Jackson School involved, both here at the bureau and in the Department of Earth and Planetary Sciences. These include the bureau's Gulf Coast Carbon Center, which is a world-leading organization in perfecting safe carbon storage and monitoring. We also have experts from TexNet, the state's seismic monitoring system that was created by and is managed by the bureau. To help determine if the mining operations will cause any seismic activity, including microseismicity that can be used to monitor the progression of carbonation. We also have researchers from the UT Hildebrand Department of Petroleum and Geosystems Engineering, Aerospace Engineering, Columbia University, the University of Bern and CarbFix. It's a large team, needed to tackle a large task!

What is the ultimate goal for this research? Are you hoping this can be applied widely?

Yes, the funding agency is DOE's Advanced Research Projects Agency-Energy, which is focused on creating marketable technologies. Our combined goal is to transform the mining industry. The urgency to find a sustainable, national supply of critical minerals is such that we have recently received an additional $1 million from DOE's National Energy Technology Laboratory to find places in the U.S. where this and other sustainable mining technologies could be applied. Our technology will not only be useful in the U.S. but in mining operations globally.

Tell me a little bit about your background. How are you applying it to the project?

You never know how different aspects of your life that you once thought were completely unrelated can conspire to come together in unexpected ways. I started my life as a geologist working on hard rocks in subduction zones. Then completely changed topics and continued to work on fractured sedimentary rocks, but unfortunately, didn't get to work on these deeper, crystalline basement-type rocks as much as I would have liked to. That is, until this project came about. It's the perfect combination of my favorite ingredients: hard rocks, fractures, and trying to change the industry for a better, more sustainable and climate-friendly future. I'm incredibly excited.



IS THERE LIFE ON EUROPA?

BY CONSTANTINO PANAGOPULOS

Scientists at the University of Texas Institute for Geophysics are working to discover if Jupiter's icy moon could support life.

PHOTO: NASA/JPL-CALTECH.

Ever since astronomers first peered through telescopes at the worlds of our solar system, people have looked to Mars for signs of life off Earth. But when scientists got a closer look at the red planet's desolate landscape, many turned their search to the outer planets and the ice-covered moons of Jupiter and Saturn.

Unlike Mars, Jupiter's moon Europa has all the requirements for life—energy, chemistry and an abundance of water in its interior ocean. But how do you spot signs of life through an ice shell that could be tens of miles thick?

That's a question that scientists at the University of Texas Institute for Geophysics are working to answer using computer simulations, field studies and a spacecraft instrument they've developed, called REASON. If all goes to plan, on Oct. 10, 2024, they'll watch REASON blast off for Jupiter aboard NASA's Europa Clipper spacecraft.

The UTIG researchers want to know whether life could have evolved on Europa—and other icy ocean worlds—and if it did, where a future lander might go to find it.

To do that, they're simulating ocean worlds to learn how warm water and nutrients circulate. And they're investigating Earth's polar ice sheets in search of exotic frozen environments and places to test their Europa prototype instrument.

The Earth-based tests are vital, but Europa is covered by an ice shell that's thicker and much older than any on Earth.

That's why UTIG researchers such as Cyril Grima and Krista Soderlund are using radar and computer simulations to probe the inner workings of icy ocean worlds and understand their prospects for harboring life.

Together with REASON's principal investigator Senior Research Scientist Don Blankenship, Research Scientist Duncan Young and graduate students such as Kristian Chan and Natalie Wolfenbarger, UTIG researchers are delivering some of the most tangible clues about what lies above, below and inside Europa's ice.

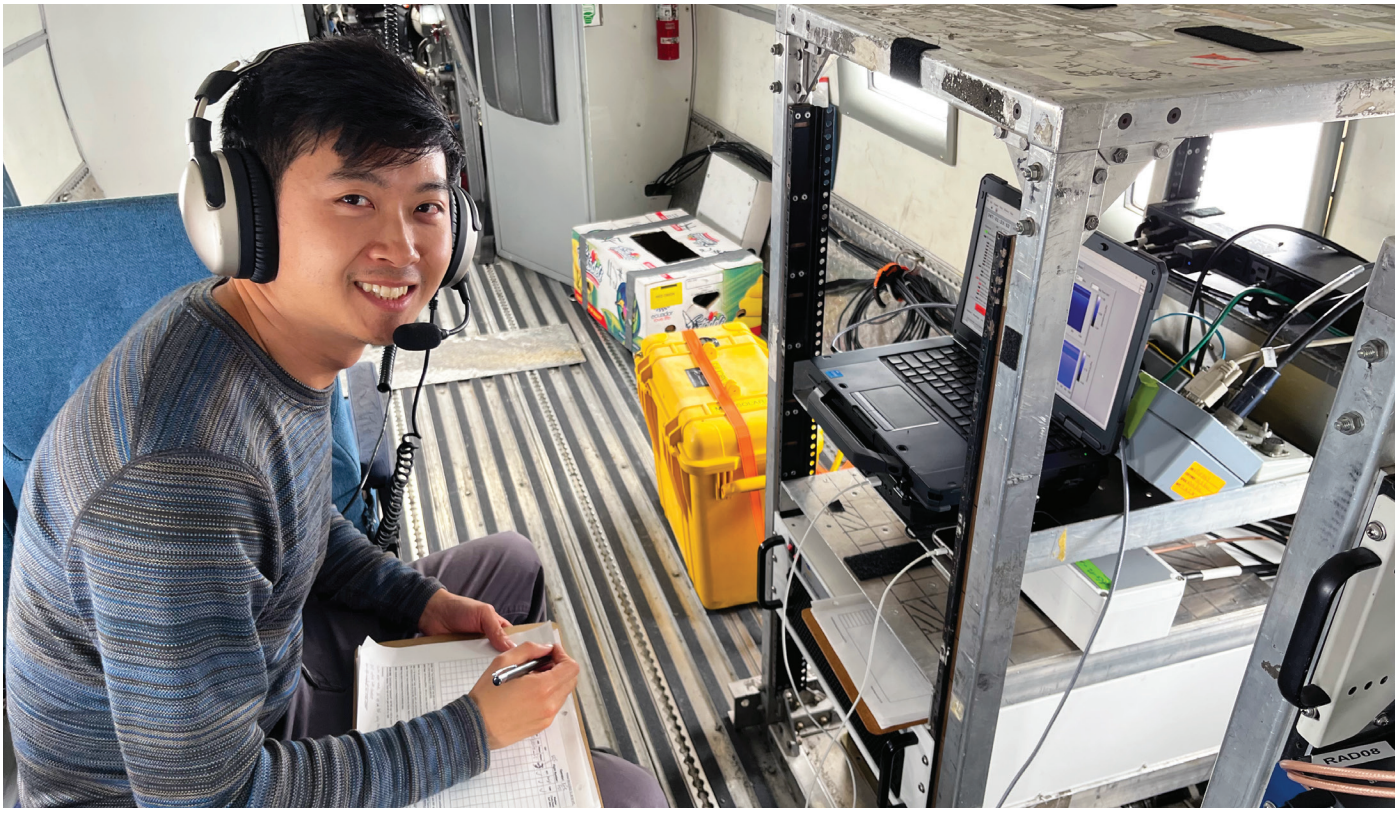
"Far from the sun's warming rays and deep within Jupiter's radiation belts, there are few less-hospitable places in the solar system than the surface of Europa," said UTIG Director Demian Saffer. "But from the depths of the oceans to the coldest places on Earth, UTIG researchers have a reputation for making scientific discoveries in extreme environments."

Ice-Penetrating Radar

On Earth, when scientists want to see what's going on inside an ice sheet, they can scan it with ice-penetrating radar the way doctors use X-rays to look inside a human body.

The reflecting radar waves tell glaciologists how thick the ice is, what it's made of, how it's shaped by ice flow or ocean currents, and where water might work its way to the surface. It's a quick way to get information about large regions of ice. It's also possible to learn how cold the ice is, what minerals are dissolved in it, whether it melted and refroze, what direction it's flowing, and so on. In short, radar can tell the story of the ice: where it's been, where it's going and how it's changed.

It's a story that UTIG researchers



ABOVE: GRAD STUDENT KRISTIAN CHAN OPERATES AN ICE-PENETRATING RADAR IN AN AIRCRAFT OVER ANTARCTICA. **PHOTO:** JAMIN GREENBAUM/UTIG.

ABOVE: REFUELING AT A FUEL CACHE DURING UTIG-LED RADAR SURVEYS OF ANTARCTICA'S CAMPBELL GLACIER, A GLACIER ON THE SIDE OF A VOLCANO. **PHOTO:** GREGORY NG.

have studied with Earth's ice sheets for decades. They're good at it. That's why NASA selected UTIG to design, test and operate the ice penetrating radar that will fly on Europa Clipper.

But there's never been an ice-penetrating radar in the outer solar system.

That's where Grima, a UTIG research associate, comes in.

Grima's background is in radar reflectometry on Mars. The European Space Agency built radar instruments for Mars 20 years ago, and they've been in orbit ever since. As a graduate student Grima came up with a statistical technique that greatly improved what the radars can reveal about the ground.

The technique was robust enough that in 2015 Grima used it to help NASA select a safe landing site to send its InSight Mars lander. Later, he applied it to the radar altimeter on NASA's Cassini spacecraft to measure inch-tall waves crossing Titan's mirror-like hydrocarbon lakes.

For Europa Clipper, Grima is working on a technique that uses radar wobbles to illuminate Europa's invisible ionosphere. It's not the mission's primary objective, but it could find important clues about plumes erupting on Europa's surface (which are thought to fuel the ionosphere).

"One of the exciting parts of Europa exploration for Clipper is that we know it's going to be full of surprises," Grima said. "Every time we get a new picture of Europa, we see something we weren't expecting. It's just a really weird, wonderful world."

Nothing aboard Europa Clipper is designed to directly detect traces of life in or around Europa. The spacecraft's primary mission is reconnaissance: map Europa inside and out and learn whether life could have evolved there.

> **"IF YOU'RE LOOKING FOR A HABITAT WHERE LIFE MAY HAVE EVOLVED, THEN EUROPA IS THE PLACE YOU GO."**
>
> **-DON BLANKENSHIP**

With Grima's help, REASON is expected to excel at reconnaissance. The next step will be to send a lander. That could be decades away, but Grima is already co-leading a group of scientists and engineers who want to make sure future spacecraft will know where to land on Europa and look for traces of life.

"When you choose a landing site, you don't want it to be too rough or too soft, but you also want to land in a place where you can do science," he said. "It's no good landing on a solid block of ice that hasn't changed for a billion years."

That means knowing what's going on in the top few feet of ice nearest the surface, where life, or its remains, might be found. Even with Grima's statistical techniques, that's a challenge.

But it's one that Jackson School grad student Kristian Chan thinks he's found an answer to.

Mapping Europa's Top Ice

Radar sounders for the subsurface work by shooting pulses of radio waves and measuring the time it takes for echoes to bounce back to the radar. Shorter radio waves react to rock and ice differently than longer ones do. By comparing different radio wavelengths, radars can calculate what reflected the wave and what the wave traveled through. Echoes that span a range of different radio wavelengths (the bandwidth) give even more detailed information about the material's properties.

Chan works with Grima and Blankenship at UTIG as a graduate research assistant. In 2023, he published research that demonstrated how different radar wavelengths and bandwidths could be analyzed together to find objects that would usually be too small to resolve with a single bandwidth.

His technique measures differences in distortion between bandwidths. To test it in the real world, Chan analyzed past radar surveys of Devon Island in the Canadian Arctic from two ice-penetrating radar instruments, each

with a different single bandwidth.

Individually, neither deep-penetrating instrument could see the upper few feet of the glacier. But by measuring differences between instruments, Chan extracted information that let him map the location and thickness of ice slabs lurking within the snow atop the ice cap.

Chan's research raised eyebrows, not because of its findings, which confirmed that the ice cap is in an advanced state of melting, but because of how well it worked.

"When I presented this to the planetary science community, they asked 'Does this actually work? Have you actually shown this?'" Chan said. "Then I pulled up Devon, and that's when it clicked. Their reaction was like, 'Oh wow.'"

For Devon Island, Chan combined two separate instruments. REASON, however, is equipped to emit radar waves across multiple wavelengths and bandwidths. In other words, the technology is already baked in.

Chan's technique means that Europa Clipper can quickly map out interesting features hiding in the upper few feet of the ice shell—features that a future lander might reach.

For Chan, the Devon Island research is a twofer: It's a new way to quickly survey Earth's fading ice sheet, and it's a robust proof of concept that REASON can look for features in Europa's shallowest surface layers.

Underwater Snow

Europa's ice sheet stretches on without end, but under the surface, the water isn't that cold. It's not all that different from the coast of Greenland where herring spawn, or the Antarctic Ocean where humpback whales forage.

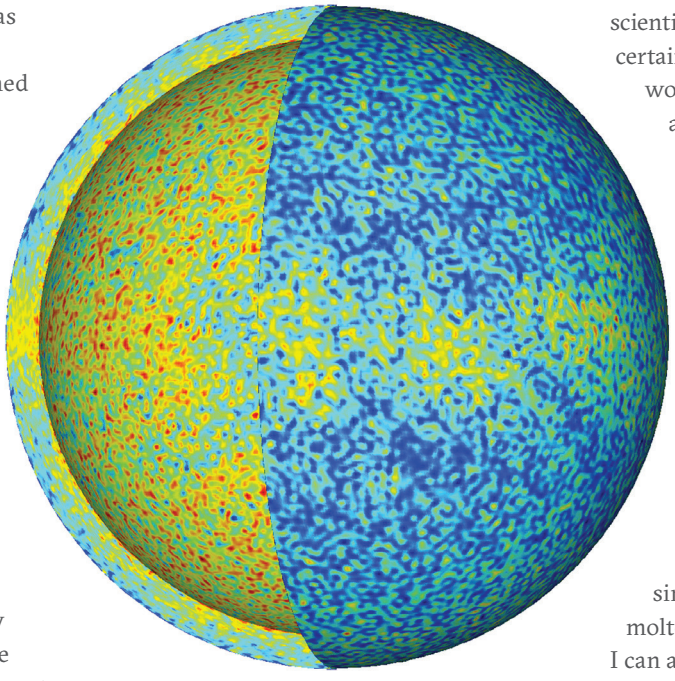
"When you look at Europa's global ice shell, it looks like a very alien environment. You've got these incredible features, almost like an egg cracking," said former Jackson School student Natalie Wolfenbarger, now a postdoctoral scholar at Stanford University. "But when you go deeper and you realize that it's overlying an ocean, there are certain conditions like the temperature and the pressure and potentially even the composition that are actually not so different from Earth."

As a UTIG graduate research assistant with Blankenship, Wolfenbarger spent her time studying exotic forms of ice on Earth. Her work took her into the weird world of frazil ice—exceptionally pure ice flakes that form out of nowhere in turbulent, supercooled seawater.

On Earth, this underwater snow rises through the water to settle on the bottom of floating ice shelves, where it traps microorganisms and even fish into the ice. Wolfenbarger's calculations suggest that this underwater snow is even more common among the inverted ice peaks and submerged ravines on the underside of Europa's ice shell.

That means Europa's shell might be purer than expected. If it is, that's important because the ice will be much more transparent to radar, and it could be a clue for whether the environment can support life.

"The salinity and composition of the ocean is one of the things that will govern its potential habitability or even the type of life that might live there," Wolfenbarger said.



ABOVE: SIMULATED 3D HEAT MAP OF EUROPA'S GLOBAL OCEAN. RED AND BLUE INDICATE WARMER AND COLDER TEMPERATURES, RESPECTIVELY. IN THIS MODEL, MORE HEAT REACHES THE ICE SHELL NEAR THE EQUATOR.
PHOTO: KRISTA SODERLUND.

Modeling Ocean Worlds

Earth's ice sheets are an excellent stand-in for Europa. But Earth is a terrestrial planet and in fundamental ways very different from an ocean world. If Europa is a snow globe with a core, Earth is a big wet rock.

Simulating the parts of worlds that are totally unlike our own is where scientists such as Soderlund, a UTIG research scientist, come in. While her research is certainly informed by observations, the worlds she recreates inside computers are largely stripped down to just fluid dynamics.

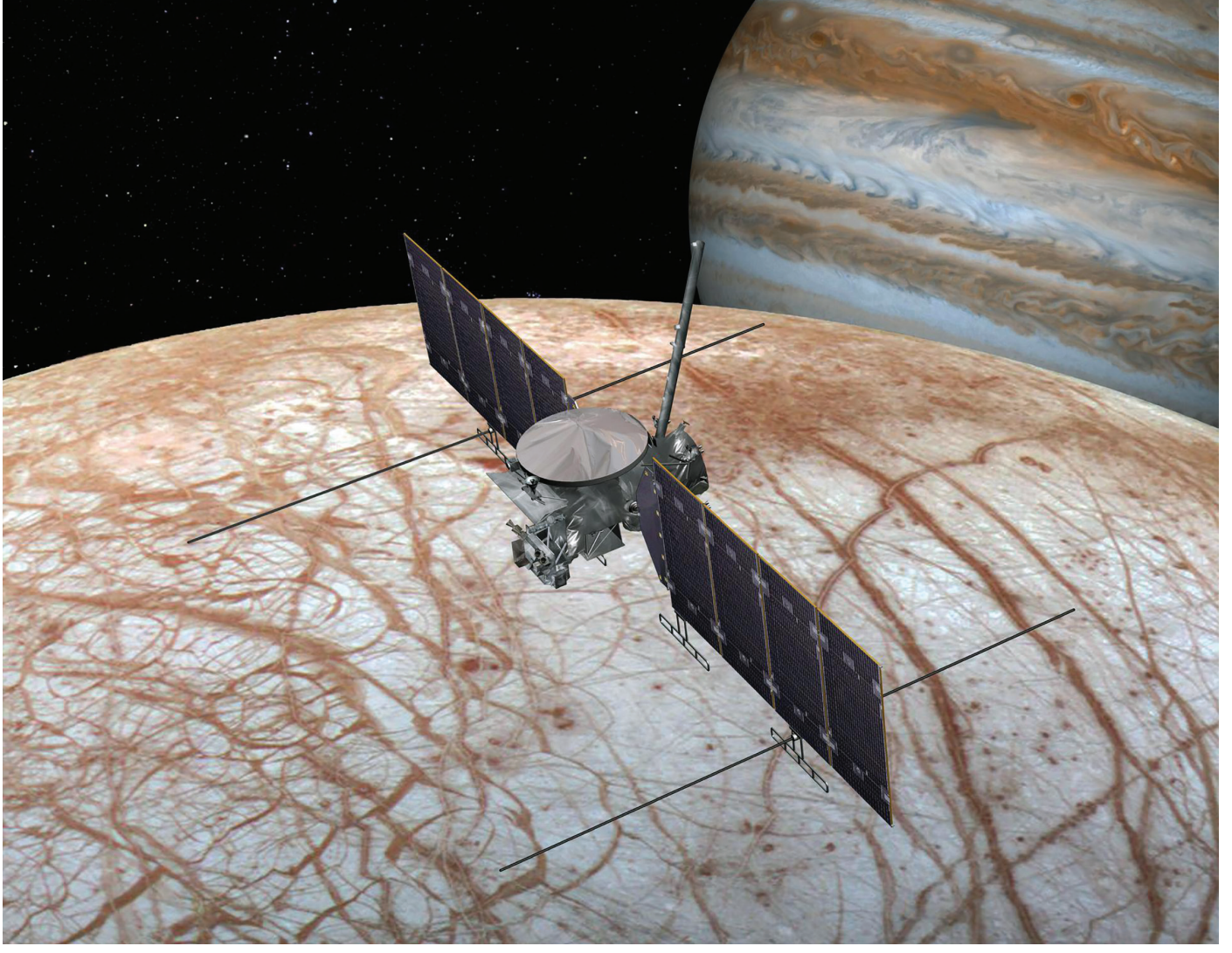
In 2014, Soderlund published one of the first global ocean circulation models for Europa. The work was based on a doctoral thesis she'd written on planetary dynamos—interior mechanisms that generate a self-sustaining magnetic field—inside Earth, Uranus and Neptune.

"These are basically really similar systems," she said. "One is a molten core, the other a global ocean. I can apply the same physics and the same numerical code."

Soderlund demonstrated that Europa's rotation directs interior heat out through the equator. The uneven warming drives complex and dynamic ocean currents.

Her results showed a world with thinner ice at the equator, where swings in pressure and temperature serve to pump plumes of purer, buoyant ice in the shell that rises and falls like a lava lamp. The predicted ice plumes matched the locations of rough "chaos terrain"—fractured topography that scientists think are created when the ice plumes push their way to the surface.

The story doesn't quite end there. Soderlund is working with Daphné



ABOVE: AN ILLUSTRATION OF NASA'S EUROPA CLIPPER ON APPROACH TO JUPITER'S MOON EUROPA. THE LONG MASTS UNDER THE SOLAR PANELS ARE PART OF THE ANTENNA SYSTEM OF UTIG'S ICE-PENETRATING RADAR INSTRUMENT. **PHOTO:** NASA/JPL-CALTECH.

Lemasquerier, a former UTIG postdoctoral researcher and now a lecturer at the University of St. Andrews, to update her computer model using a different idea about how the icy moon's interior is heated.

"Until now, we'd assumed heating is driven by radiogenic decay in the rocky mantle," she said. "But if it's also being heated by tidal dissipation in the rocks, the heat flux is going to be less uniform and much stronger at the poles."

In the new model, the ocean at the poles is warmer than it is at the equator. With so little direct evidence of what's really going on inside Europa, Soderlund knows that she'll have to wait for Clipper to get there to learn which model is right. Until then, Soderlund will continue testing different scenarios using physics, new observations and what she calls "a little wild speculation."

The Best Place to Look for Life

Assuming the 2024 launch is successful, it will be more than five years before Clipper closes the 380-million-mile gap to Jupiter and sends back its first radargram.

Young already has the date marked on his calendar: March 27, 2031.

The wait will have been worth it. Mars may have its attractions as our best-studied neighbor, but researchers know that the search for extraterrestrial life has to include a different, icier kind of world.

"Europa has always been special," said Blankenship, who leads REASON's development both at UTIG and Caltech's Jet Propulsion Laboratory. "If you're looking for a habitat where life may have evolved, then Europa is the place you go."

Ice is the most common environment in our solar system. On ocean worlds like Europa, it's all encompassing, while on rocky ones like Earth, the ice sheets cover only certain regions. But in every case the ice is a mirror that tells a story of the geology and, at least for Earth, the biology within.

"Earth is profoundly shaped by life. It seeps into every facet in every scale of how this planet works," Young said. "If Europa has had life at similar timescales, I wouldn't be surprised at all if we find it's had profound influences on the ice shell."

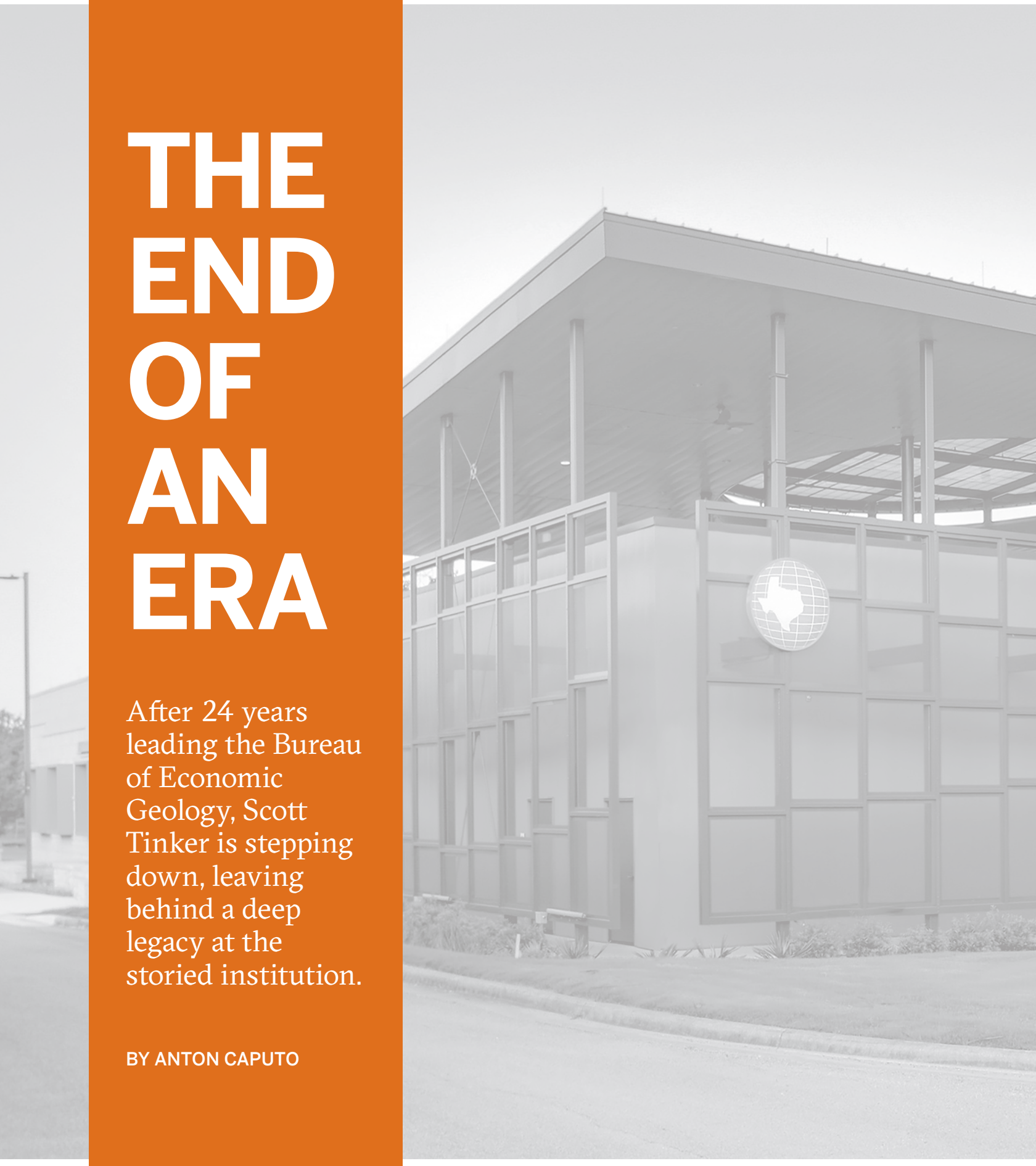
Whatever REASON sees when it first looks down on Europa's icy surface, it will mark a massive achievement for everyone involved.

But the scientific discoveries the UTIG researchers have already made about radar, ice sheets and ocean worlds will leave a legacy of their own. It's a legacy that Blankenship, Young, Grima, Chan, Wolfenbarger, Soderlund and their fellow UTIG researchers will build on as they continue to explore ice sheets on Earth and other worlds.

THE END OF AN ERA

After 24 years leading the Bureau of Economic Geology, Scott Tinker is stepping down, leaving behind a deep legacy at the storied institution.

BY ANTON CAPUTO



It is difficult to put the Bureau of Economic Geology into a tidy box. It is the oldest research unit at The University of Texas at Austin, dating back to 1909, and the second largest. Yet it doesn't rely on faculty members for leadership or research.

It is a place where hundreds of students have received valuable hands-on experience and mentoring over the years, but education is not the major focus. It is a research institution organized more like a national lab than an academic department, and it is the state of Texas' geological survey, meaning it has an official role in informing state policymakers about the natural resources and the environment of Texas.

And looming over all this is the fact that it is largely a soft money institution, meaning its very lifeblood depends on attracting external investment from industry partners, science foundations and government agencies. If not, it withers.

Given this combination of factors, it takes a versatile and visionary individual to successfully lead the bureau. For over two decades, that person has been Scott W. Tinker. Now, after 24 years at the helm, Tinker has decided that the bureau would benefit from new leadership.

"I am firing myself!" he said. "It's been a remarkably great ride. But I think it's time for somebody new to take the helm. I could probably do another 10 years, and things would be fine. But this is the right time for new ideas, new energy and new innovation. I believe that the best thing I can do for the bureau is create an opportunity for that to happen."

Tinker's impact is undeniable. He has been instrumental in starting a host of high-profile research programs. He has spearheaded the addition of major facilities such as the Houston Research Center, the Austin core repository, and many research labs. He played a pivotal role in the formation of the Jackson School of Geosciences, helping secure the foundational gift from Jack and Katie Jackson as part of a small group of people that Jack Jackson dubbed "The Jackson Five."

Tinker has been a tireless advocate for energy and environmental education and communication through film, television, radio and other media. But mostly there's the seemingly boundless commitment to promote —and sometimes protect—the bureau in a dizzying array of arenas that includes academia, industry, international business, nongovernment organizations, the Texas Legislature, and national policy debates.

Bill Fisher, a former bureau director and founding dean of the Jackson School, said that Tinker's success is rooted in understanding the needs of a unique organization like the bureau and being able to thrive in the uncertain environment it takes to lead it. This takes a rare skill set that involves understanding how to look for and develop new research opportunities, even in areas outside of your expertise, and knowing how to go about opening the doors and forging the relationships to make them happen.

"That involves somebody who is willing to get out of the office and have a lot of visibility. Scott appreciated that very quickly," Fisher said. "That visibility helps a whole lot in trying to attract and keep the money flowing. All the good ideas in the world aren't worth a damn if you don't have the money, and same for all the money in the world if you don't have good ideas. Scott is very intelligent. He has good ideas and he pushes them."

Time for a Change

When Tinker decided to throw his hat into the ring for the top spot at the bureau nearly a quarter-century ago, it was the opportunity to grow something "unique" that drew him. He was particularly intrigued by the bureau's position at the nexus of academia, industry and government.

At the time, Tinker was coming from a 17-year career mostly in the research side of the oil industry, where he was an advanced senior geologist at Marathon Oil's Petroleum Technology Center in Littleton, Colorado.

He was familiar with the bureau from its national reputation and through fieldwork with bureau researcher and current Jackson School Professor Charlie Kerans.

The two met in the field in the late 1980s when Kerans had just started the bureau's reservoir characterization research lab. Kerans remembers Tinker being tremendously energetic in the field and on the cutting edge of the latest technology and research.

"Scott was pretty much at the forefront of 3D modeling technology," Kerans said. "He pushed a lot of the technology forward very quickly and very effectively."

The two kept in touch for years, teaching short courses together on carbonate reservoirs and publishing a book together in 1997: "Sequence Stratigraphy and Characterization of Carbonate Reservoirs." So, when the bureau was looking for a director, Kerans was thrilled to hear about Tinker's interest. But he was also surprised, given that Tinker would have to leave a thriving research career for administration.

Tinker and his family also had much going on at the time. He and wife Allyson had a busy family life with three young boys—Nathan, Derek and Tyler. But it was an era when most major companies were closing research labs. At the bureau, Tinker saw an opportunity to make a move to a place where he could grow and diversify research.

"I saw the opportunity to create something that the world recognizes," Tinker said. "I thought, what a bunch of great clay. Let's try to mold this."

Needless to say, he got the job.

Broadening the Scope

When Tinker entered the bureau in January of 2000, there was a lot of work to do. The research unit was at a financial low point. Previous leaders had

focused on a few international projects, which had petered out for a variety of political and economic reasons. Fisher had stepped in as interim director to stabilize the situation and to find the next permanent director. When he met with Tinker for a breakfast meeting in Denver during the annual Geological Society of America meeting in 1999, he immediately saw the potential.

"I found the guy tremendously articulate and pretty darn insightful," Fisher remembers. "I went back and told Doug Ratcliff (bureau associate director), I think I just found our next director."

The next 24 years would be defined

by growth at the bureau. Research funding grew from about $10 million a year when Tinker took over to more than $30 million a year today. The number of employees grew from fewer than 100 to about 250. And with the exception of temporary furloughs that were necessary during the worst of the COVID-19 pandemic, staffing at the bureau has been remarkably stable.

"We have had folks here 30 to 40 years or more," Tinker said proudly. "As long as they are actively contributing and happily engaged, the bureau is a great home. At the end of the day, our success is mostly about our people. When I arrived, the first thing I did was write a list of names and technical disciplines on a white board. We have since hired over 500 people."

Much of that growth and success can be linked to Tinker's deft navigation of a changing energy and environmental landscape in Texas, across the nation, and around the globe. Oil and gas still remain the backbone of the energy system, but energy sources are diversifying as lower-emissions technologies and options are added. And there is a growing recognition of the need to understand the broader effects of energy production, including emissions and other environmental impacts. Tinker has made sure that the bureau has stayed ahead of the curve when it comes to conducting research in these areas.

Some of the programs that have either started or significantly expanded under Tinker's leadership include: the most comprehensive public study of the nation's seven major shale plays; the state's seismic monitoring system, TexNet, and a related research consortium to understand the cause of increased seismicity in Texas, CISR; a plethora of research consortiums, including ones in hydrogen energy, geothermal energy, unconventional reservoirs, mudrocks and computational seismology; the Gulf Coast Carbon Center, the nation's top carbon storage research program; a cutting-edge subsurface micro- and nano-sensor program; and recently, a project to conduct a cradle-to-grave analysis to determine the environmental impact and cost of electricity generation options (see story on page 41).

"He built great programs and he certainly put the name of the bureau on the map across the country and beyond," said Sharon Mosher, who was dean of the Jackson School from 2009 to 2020. "He really grew the bureau into what it is today."

Spreading the Word

At the same time Tinker helped build the bureau into a research power house, he has been a tireless advocate for energy and science education in the public sphere.

He conceived of and is the voice of "EarthDate," a radio program produced by the bureau with a reach of more than 450 radio stations in all 50 states and abroad. "EarthDate" will air its 350th episode in January 2024. He conceived of, hosts and moderates the TV talk show "Energy Switch," which reaches over 100 million households on PBS and explores hot-button topics in energy and climate with two global experts as guests on each show.

Tinker is also the founder and chairman of the Switch Energy Alliance, an energy education nonprofit. The organization offers free K-12 classroom curriculum and materials used by thousands of teachers nationwide, hosts an international case competition for college students, and creates documentaries and educational films and videos. With director Harry Lynch, whom Tinker describes as brilliant, patient and creative, Tinker has co-produced and been the on-screen guide in two feature-length documentaries, "Switch" and "Switch On," which explore the global impacts of different energy sources. This includes shining a light on "energy poverty" — the array of impacts that communities with unreliable access to energy face — and the myriad benefits that come with expanding access to energy.

The past 24 years have also given Tinker the opportunity to mix with heavy hitters inside and out of the public policy realm.

OPPOSITE PAGE, TOP: SCOTT TINKER TEACHING IN THE FIELD.
PHOTO: BUREAU OF ECONOMIC GEOLOGY.
OPPOSITE PAGE, BOTTOM: SCOTT TINKER (SECOND FROM RIGHT) WITH CHARLIE KERANS IN THE BIG HATCHET MOUNTAINS IN NEW MEXICO WHEN TINKER WAS WORKING FOR MARATHON OIL IN 1999. KIRT KEMPTER (SECOND FROM LEFT) AND JASON RUSH (FAR LEFT) ARE ALSO PICTURED.
PHOTO: SCOTT TINKER.

LEFT: FORMER TEXAS GOV. RICK PERRY (LEFT) AND SCOTT TINKER.
PHOTO: SCOTT TINKER.

"I met Henry Kissinger and Walter Cronkite, many state governors and Cabinet secretaries, Earl Campbell and Andy Roddick, dozens of industry CEOs, university presidents and elementary students," he said. "It has been an incredible ride, really."

Yet, when Tinker looks back on his years and accomplishments, he doesn't focus on specific research initiatives or movie premieres, but instead dives into the commitment and support of the people around him.

Wanda LaPlante, who served as Tinker's first executive assistant for a decade, said that during his early days at the bureau, he spent long hours getting to know everyone in the organization by meeting and listening to people. She remembers being struck at how Scott and Allyson balanced the demanding new life with three young sons, and daughter Claire soon on the way.

"It was very much a family feeling for me," she said. "He (Tinker) really cared. He's very compassionate and really wants to do the right thing."

The bureau's culture under Tinker also became distinctly international. He likes to quip that when he first started, the bureau employed people from three countries: Texas, Oklahoma and Louisiana. Now, there are full-time staff members at the bureau from six continents representing at least 25 nations. That's a tribute to the bureau's global reputation, he said, and its efforts to cast a wide net to bring different skill sets and perspectives to solve scientific problems.

"We've got different cultures, socioeconomic backgrounds, educational backgrounds, government systems," Tinker said. "That type of diversity is not always easy to manage, but very powerful."

Looking back on his years at the bureau, Tinker said he has reflected on what it has meant to him. He credits many people with helping along the way, particularly wife Allyson, his visiting committee members, wise researchers such as Martin Jackson and Shirley Dutton, LaPlante, state geologist colleagues including Jon Price and Nick Tew, and past directors Fisher and Peter Flawn (a former UT president and bureau director who passed away in 2017). These and many others were always willing to lend an ear and their counsel, he said.

"I had lunch with Peter Flawn a few days before he passed," Scott recalled. "He chaired the bureau's visiting committee that I formed back in 2000 and remained a wonderful mentor. Peter was a man of few words, but said to me that day, 'I often wonder what would have happened to the bureau if you had not arrived.' That meant a lot to me."

Teamwork is Key

The bureau became part of the Jackson School in 2005, when the school was formed. Although an academic unit, it operates more like a research business, from how research is funded to how teams of scientists are organized, to how it is staffed.

For instance, being a soft money organization, the bureau can't run its account balances down to zero at the end of a fiscal year.

"Our full annual budget does not arrive at the beginning of each fiscal year. Instead, we are on a continuous treadmill to bring money in to support our scientists throughout the year," said Deputy Director Jay Kipper, who has acted as a combination of chief financial officer and chief operating officer for two decades. "It's very different than the way the rest of the university works."

And on the research side, it is common for bureau research teams to employ engineers, scientists,

economists and experts from other fields on a project. According to Tinker, this creates an environment where fundamental research is conducted in service of practical problems, and where researchers can thrive and expand their impact by working as a team.

Senior Research Scientist Julia Gale said this arrangement benefits the science and scientists. She began her career at the bureau just before Tinker took over. She was a little nervous about the soft money aspect of the organization, particularly since it was at a time when the organization was facing funding issues and looking for a new leader.

Very soon, she said, she was immersed in a "phenomenal team atmosphere" while working at the bureau's Fracture Research and Application Consortium (FRAC) that was unlike anything she had experienced at academic institutions. And she found the bureau under Tinker's leadership to be very nimble and thoughtful with its employees, allowing them to move from one project to another to align skills with the available opportunities.

"One of the advantages of being in a team is that if you don't have a good idea, maybe somebody else will," Gale said. "That's a nice dynamic to have. You try your best to get good ideas and follow through, but you know that the others in the group are going to have your back."

Michael Young, a senior research scientist at the bureau and current Jackson School associate dean of research, served as Tinker's associate director for the environmental division from 2010 to 2020. He came to the bureau from the Desert Research Institute, where he was acting executive director of the Division of Hydrologic Sciences, which he describes as a fairly typical academic setting. One of the keys to the bureau's success, he said, is finding people who can thrive under the research model that Tinker has nurtured.

"We focus on people who really want to do collaborative research," Young said. "We have a lot of broad comprehensive research groups and programs that are successful. That is really a totally different type of model than you would see at most academic departments."

A Lasting Legacy

One of the overarching accomplishments that Tinker is credited with is diversifying and expanding the bureau's funding sources and research initiatives by keeping the bureau active on the national and international scenes. International examples include major projects with Pemex, Mexico's national oil company; several projects in China; a carbon storage research agreement with Trinidad and Tobago; and a resource analysis project in Timor-Leste (see page 12). But nowhere has the success been more evident than inside the state of Texas and with the bureau's role as geological survey.

Every state has a geological survey. Their roles vary, depending on the laws and traditions of each state, but most act as a resource for legislators and policymakers. According to Nick

OPPOSITE PAGE, TOP: (LEFT TO RIGHT) SCOTT TINKER WITH FORMER UT PRESIDENT AND BUREAU DIRECTOR PETER FLAWN AND FORMER JACKSON SCHOOL DEAN AND BUREAU DIRECTOR BILL FISHER.
PHOTO: BUREAU OF ECONOMIC GEOLOGY.
OPPOSITE PAGE, BOTTOM: SCOTT TINKER IN THE COLOMBIAN VILLAGE OF GUNCHUKWA WITH LOCALS IN 2018 DURING HIS WORK WITH SWITCH ENERGY ALLIANCE.
PHOTO: SWITCH ENERGY ALLIANCE.

ABOVE: SCOTT TINKER AT THE BUREAU OF ECONOMIC GEOLOGY'S 100TH ANNIVERSARY CELEBRATION IN 2009.
PHOTO: BUREAU OF ECONOMIC GEOLOGY.

Tew, the director of the Alabama Survey and former president of the Association of American State Geologists, under Tinker's leadership the bureau has become a geological survey that stands apart.

"The main difference is that the bureau is a very large survey that operates on an entrepreneurial model," he said. "Success under this model requires visionary and creative leadership from the director and senior staff. Scott and his team have provided this type of leadership for 24 years."

Successes include funding for the statewide TexNet seismic monitoring system and the connected research consortium Center for Injection Seismicity Research (CISR) to address increased seismic activity, working with the General Land Office on coastal erosion issues, and other projects with the Texas Water Development Board, the Texas Railroad Commission and the Texas Commission on Environmental Quality.

There's also the state's investment in the bureau's STARR program, which conducts research to increase the production and profitability of the state's earth resources, to support public education. Since its founding in 1996, state funding has grown from about $500,000 a year to $5 million a year. That increase, Tinker said, came under the leadership of state Comptroller Susan Combs, who was a member of the bureau's Visiting Committee at the time.

And it has certainly paid off. Over $500 million—or 13 times the cost of the program—has been returned to Texas through increased royalties and severance taxes since the program began.

Kerans credits Tinker directly with fostering the bureau's relationship with state agencies. Before Tinker arrived, he describes the bureau as having little status or influence in the Legislature.

"I think Scott had gotten us to a point with the state where we never were," he said.

According to Young, much of the success experienced by the bureau during Tinker's tenure stems from Tinker's ability to hire the right people as his associate directors and trusting them to do their jobs. This has freed up Tinker to forge the relationships that will ultimately pay off in research support, and to stay ahead of important scientific trends and needs.

"Scott has the job of flying at a 30,000-foot view, looking at how things are going to change in the next three to five years and trying to make those connections and getting those doors open," Young said. "He opens those doors, and then eventually it's up to us to make a compelling case for the work we want to do."

Tinker agrees with Young's assessment of the bureau's associate directors and points to them as key to the bureau's success, particularly with the flat organizational structure.

"My associate directors are remarkably talented and highly experienced leaders," Tinker said. "They bring deep industry and military experience to the bureau, run their divisions, and we knit it all together into a nice bureau fabric. It's vital for me to delegate responsibility and authority, and support them behind the scenes so that they can do their jobs effectively."

According to Kipper, that involves keeping one simple reality in mind.

"We try to eliminate bureaucracy and excessive management so that the researchers can really focus on their research and get it out in publications and presentations, because at the end of the day, the bureau's reputation is built by our people."

Even with Tinker stepping down, he is not likely to disappear any time soon.

He's staying until a replacement director can be found and then will take on a part-time role based in Houston. There, he will continue his work to "open doors" for bureau researchers. He also plans to continue lecturing around the globe—he does an average of 60 keynote and invited lectures a year at conferences, universities, in board rooms and beyond—and advancing energy education. This includes his work on energy poverty, an effort to ensure that energy poor nations aren't forgotten as the world continues to search for the energy answers of the future.

There have been only eight directors in the bureau's 114-year history. Tinker said it's an honor to be among them.

"It has been a true privilege to serve the bureau. It provided a unique opportunity for us to impact global society in a meaningful way," Tinker said. "Now it's time for someone else to have that remarkable opportunity."

ABOVE: (LEFT TO RIGHT) SCOTT TINKER WITH BUREAU ASSOCIATE DIRECTORS MARK SHUSTER AND MICHAEL YOUNG AND DEPUTY DIRECTOR JAY KIPPER AT A FOURTH OF JULY COOKOUT HOSTED BY THE BUREAU. **PHOTO:** BUREAU OF ECONOMIC GEOLOGY.

SCOTT TINKER AT A GLANCE

Education

- Trinity University, Bachelor of Science in Geology and Business Administration, 1982
- University of Michigan, Ann Arbor, Master of Science in Geological Sciences, 1985
- University of Colorado, Boulder, Ph.D. in Geological Sciences, 1996

Professional and Academic Service

- American Association of Petroleum Geologists (AAPG): President 2008-2009; Distinguished Ethics Lecturer 2005-2006, 1997; Member since 1982
- Jackson School of Geosciences Executive Committee: 2001-present
- Society of Petroleum Engineers (SPE): Distinguished Lecturer 2002–2003; Member since 1982
- Association of American State Geologists (AASG): President 2006-2007; Member since 2000
- Geological Society of America (GSA): Fellow; Halbouty Distinguished Lecturer 2013

Current Boards, Councils and Commissions

Academia

- Trinity University Board of Trustees
- Jackson School of Geosciences Executive Committee
- University of Michigan Department of Geosciences Advisory Board

Federal and State Government

- National Petroleum Council, U.S. Secretary of Energy appointment
- The Energy Council
- Interstate Oil and Gas Compact Commission
- TexNet Technical Advisory Committee

Private Sector

- Switch Energy Alliance 501(c)(3), Chairman of the Board and Founder
- Shell Science Council
- Southwest Research Institute Advisory Trustee
- Deep Isolation, Advisory Committee

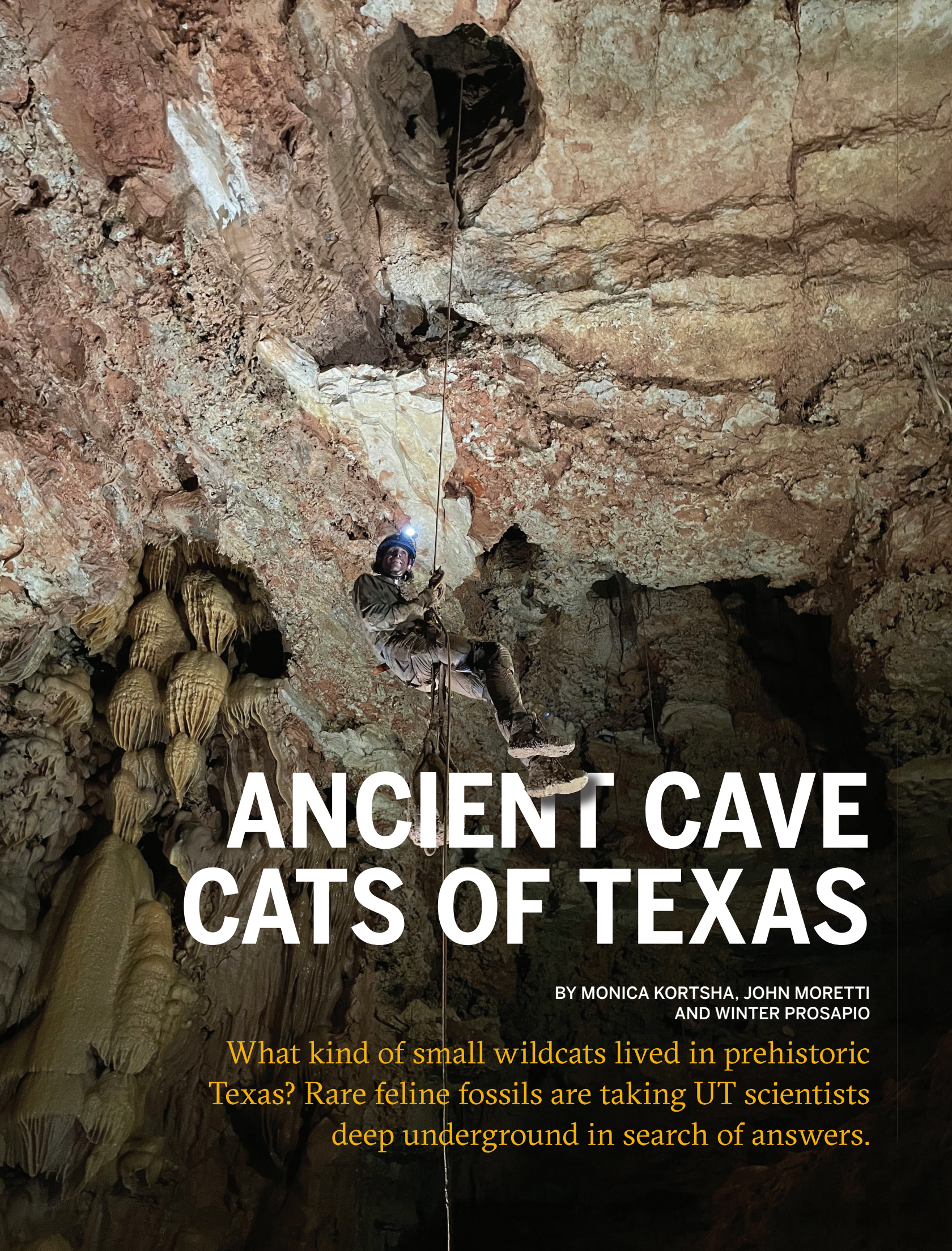
Policy and Government

- Appointed to National Petroleum Council (NPC) in 2006; currently serves on the NPC's Committee on Resource Development
- Appointed to the Interstate Oil and Gas Compact Commission (IOGCC) in 2007
- Served on the National Academies National Research Council Board on Energy and Environmental Systems (BEES) from 2003 to 2009
- Served as the director of the Petroleum Technology Transfer Council (PTTC), heading the Texas Regional Lead Organization from 2000 to 201
- Former member of the National Academies Roundtable on Oil and Gas and the Aspen Institute's Shale Governance Forum

Awards

- AGI Campbell Medalist
- AAPG Halbouty Medalist
- GCAGS Boyd Medalist
- American Institute of Professional Geologists (AIPG) Parker Medalist
- Geological Society of America (GSA) Fellow

ABOVE: THE TINKER FAMILY: (LEFT TO RIGHT) NATHAN, SCOTT, ALLYSON, CLAIRE, DEREK AND TYLER.
PHOTO: SCOTT TINKER.



ANCIENT CAVE CATS OF TEXAS

BY MONICA KORTSHA, JOHN MORETTI AND WINTER PROSAPIO

What kind of small wildcats lived in prehistoric Texas? Rare feline fossils are taking UT scientists deep underground in search of answers.


THE UNIVERSITY OF TEXAS
BUREAU OF ECONOMIC GEOLOGY
VERTEBRATE PALEONTOLOGICAL COLLECTIONS
NO. 40600
Felis rufus
assorted limb, ribs, and skull bones
FORMATION Pleistocene
LOCALITY Natural Bridge Cave
COLLECTOR B. Frank

PREVIOUS PAGE, LEFT: DOCTORAL STUDENT JOHN MORETTI DESCENDS INTO THE INFERNO ROOM, A CAVE CHAMBER, TO RECOVER ANCIENT WILDCAT FOSSILS.
PHOTO: CHRIS HIGGINS/NATURAL BRIDGE CAVERNS.
PREVIOUS PAGE, RIGHT: SMALL WILDCAT FOSSILS COLLECTED FROM THE DUNGEON IN 1963. THE FOSSILS ARE HELD IN THE JACKSON SCHOOL'S VERTEBRATE PALEONTOLOGY COLLECTIONS.
PHOTO: NATURAL BRIDGE CAVERNS.

Located just north of San Antonio, Natural Bridge Caverns is one of the most popular tourist destinations in Central Texas. Each year, over 250,000 visitors venture underground to marvel at its massive chambers and dramatically lit formations.

But there is more to Natural Bridge Caverns than what is open to the public. The caverns are the largest in the state by volume, with most of that area being "wild cave."

In the undeveloped dark, discoveries are still being made.

Last year, while exploring the cave, the caverns' co-owner and CEO, Brad Wuest, found fossilized bones from a small wildcat that potentially lived thousands of years ago. The bones, which were from a feline about the size of a large house cat, were located at the bottom of an 80-foot drop in a chamber called The Dungeon.

Wildcat bones are rare in the fossil record. But it wasn't the first time they had been found in The Dungeon. In 1963, caver Orion Knox, who was among the first to explore Natural Bridge Caverns, found a selection of small wildcat bones in the same chamber. These bones were retrieved by Rueben "Bud" Frank, then a geology graduate student at The University of Texas at Austin, and brought back to the vertebrate paleontology collections at UT for safekeeping.

But it looked to Wuest that Frank may have left some bones behind in the cave.

Wuest called John Moretti, a doctoral student and paleontologist at the Jackson School of Geosciences, to tell him about the discovery—and to see if he was interested in picking up where Frank had left off decades before.

Moretti had questions: Did the bones actually belong to the incomplete wildcat in the UT collections? What kind of cat was it, and when did it live? And how did it end up in the darkness of The Dungeon, almost a mile underground?

He accepted the mission to retrieve the bones and began the search for answers. Little did he know that there would be even more cats to come.

Cryptic Cats

Moretti studies how animal communities have changed over the past couple of million years—a geologic time interval known as the Quaternary Period that ranges from about 2.5 million years ago to today.

Although past wildlife surveys have documented a diverse array of small wildcats that are now rare or absent in the state, such as jaguarundis, ocelots and margays, the feline fossil record of Texas is woefully sparse.

Not counting bobcats, there are just 10 wildcat specimens from five sites in the state, with six of those specimens from a single site—Schulze Cave in Edwards County. Count bobcats and you get just 20 more cats. Most of these wildcat specimens are represented by lone bones and fragments, according to Moretti.

Wuest's discovery offered a much more complete look—consisting of multiple bones from different parts of the body.

"This material from Natural Bridge is really exciting because it's way more than just a single jaw or isolated tooth," Moretti said. "We have more material to deal with. There's more morphological evidence available, and therefore, more potential to observe traits that may be diagnostic or distinctive."

The fact that the cat remains had been preserved in a cave—a natural climate-controlled environment—also raised the possibility they could contain something the other bones did not: pristine traces of ancient DNA.

DNA could provide a new avenue for determining what species of wildcat lurked in the caverns perhaps thousands of years ago. That's important, Moretti said, because it's difficult to determine what species a wildcat belongs to based on bones alone.

Over the years, the small wildcat remains from The Dungeon in the UT collections have been tentatively classified by different people as a number of different felines. The potential contenders include a bobcat,

BELOW: A VIEW OF THE HALL OF THE MOUNTAIN KING, A PUBLIC AREA OF THE CAVE. AFTER THIS CHAMBER, THE CAVE SYSTEM IS "WILD" AND OFF LIMITS TO THE PUBLIC.
PHOTO: CHRIS HIGGINS/NATURAL BRIDGE CAVERNS.

margay, an extinct species known as a river cat, and jaguarundi. The wobbly identity is in part due to anatomical similarities shared by small wildcat skeletons across species, Moretti said. But another issue is that there aren't very many wildcat bones available for comparison in the first place.

The newly discovered bones and potential DNA could give scientists the clues they need to sort out the identity of the ancient cave cat—which could aid in further identification efforts.

"Once we have a partial skeleton, not just isolated bones, we can analyze the utility of traits that have been used in the literature [to identify small wildcats]," Moretti said. "That may help refine our ability to identify these animals, period, in any context."

But Moretti would need some help determining if ancient feline DNA was there in the first place. That's where David Ledesma, a doctoral student specializing in ancient DNA extraction, came in.

Ledesma works closely with paleobiologist Melissa Kemp, an assistant professor in the UT College of Natural Sciences who specializes in using ancient DNA fragments to identify reptile and amphibian fossils from cave samples. He said a wildcat offered an exciting new opportunity.

"I usually extract DNA from much, much smaller fossils," said Ledesma, who earned his undergraduate degree from the Jackson School. "When I first heard about [the wildcat], I was interested in helping out."

Before that could happen, Moretti had to bring back the bones. As he underwent specialized training to safely navigate the cave, a Natural Bridge Caverns team continued to explore and make amazing feline finds.

"THIS MATERIAL FROM NATURAL BRIDGE CAVERNS IS REALLY EXCITING BECAUSE IT'S WAY MORE THAN JUST A SINGLE JAW OR ISOLATED TOOTH."

-JOHN MORETTI

Meanwhile, More Cats

It started with pawprints. In March 2022, the team discovered cat tracks pressed into the muck of a passageway near the drop into The Dungeon. Four days later, they found the remains of another small wildcat.

This specimen was nearly complete, with the bones scattered in a large chamber called The Inferno Room. The chamber is accessed via a 60-foot drop in an overlying passageway. Near the drop, the team found even more wildcat tracks.

The pawprints in the passageways preserved something rare in the fossil record: a sense of what an animal was feeling. The tracks eerily conveyed the discomfort of being in the total darkness of the cave. They showed a cat covering the same ground over and over, and attempting to climb up the wall before sliding back down, claws dragging.

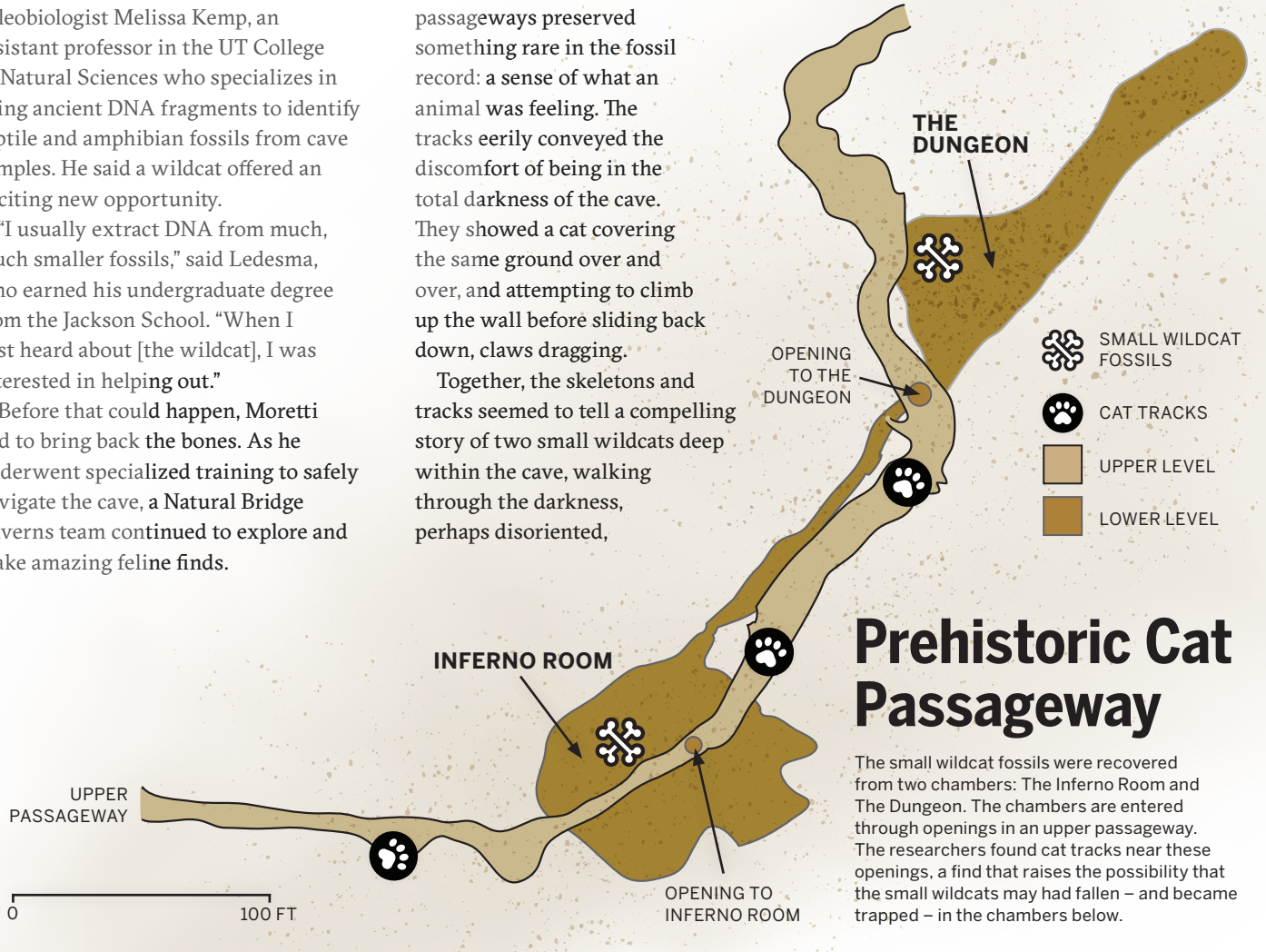
Together, the skeletons and tracks seemed to tell a compelling story of two small wildcats deep within the cave, walking through the darkness, perhaps disoriented, slipping down different drops until they fell to their deaths in The Inferno Room and The Dungeon.

The narrative was instantly appealing, but Moretti was cautious about jumping to conclusions. It would take more research to match the tracks to foot bones from the cave cats below. But that didn't stop him from being astounded by what the expedition team was finding.

"One ancient small wildcat skeleton was, alone, remarkable," Moretti said. "Two skeletons, close together and seemingly associated with a trackway—that was unheard of."

That was before the third wildcat skeleton.

This cat was found much closer to the entrance in a passageway known as Discovery Crawl. Based on the age of other bones previously found in the passageway, including now regionally extinct black bears, this feline met its end maybe a century or so ago—much



Prehistoric Cat Passageway

The small wildcat fossils were recovered from two chambers: The Inferno Room and The Dungeon. The chambers are entered through openings in an upper passageway. The researchers found cat tracks near these openings, a find that raises the possibility that the small wildcats may had fallen – and became trapped – in the chambers below.

LEFT: MORETTI PREPARES TO ENTER THE DUNGEON.
PHOTO: TRAVIS WUEST/NATURAL BRIDGE CAVERNS.

more recently than the other two cave cats found deep underground.

By January 2023, everything was in order to recover the fossils. A specialized wildcat expedition team had come together to assist Moretti and document the mission. The team included Natural Bridge Caverns co-owners and brothers Brad and Travis Wuest; John Young, a paramedic with experience in cave rescue; and Chris Higgins, a world-renowned cave photographer.

All that was left to do was to go get those cats.

Back Together Again

It took three days to carefully chart, pack and transport the fossils from deep within the cave. But by the end of the third day, the two cats were back at the surface again, perhaps for the first time in millennia, and safely settled into a drawer in the UT collections. A couple of weeks later, they were joined by the third cat from Discovery Crawl.

One of the first things Moretti did after retrieving the fossils was to compare the bones he recovered from The Dungeon with those collected from the chamber 60 years ago. It was no question that they had come from the same cat. Some of the bones in the collection fit right back into slabs of flowstone surrounding many of the recently retrieved fossils.

"It's very clear that what we collected this year and what they collected in 1963 was one individual skeleton clustered together," Moretti said.

"IT'S VERY CLEAR THAT WHAT WE HAVE COLLECTED THIS YEAR AND WHAT THEY COLLECTED IN 1963 WAS ONE INDIVIDUAL SKELETON CLUSTERED TOGETHER."

-JOHN MORETTI

It looked like Frank, the UT graduate student from the 60's, had focused on bringing back the most accessible fossils, ones that could be pried from the rock without breaking. The rest were left behind for Wuest to find six decades later.

In the long run, that may have been for the best. Ancient DNA extraction and sequencing technology didn't exist when the first batch of bones was brought back from The Dungeon. Now, Moretti and Ledesma could start the process right on campus.

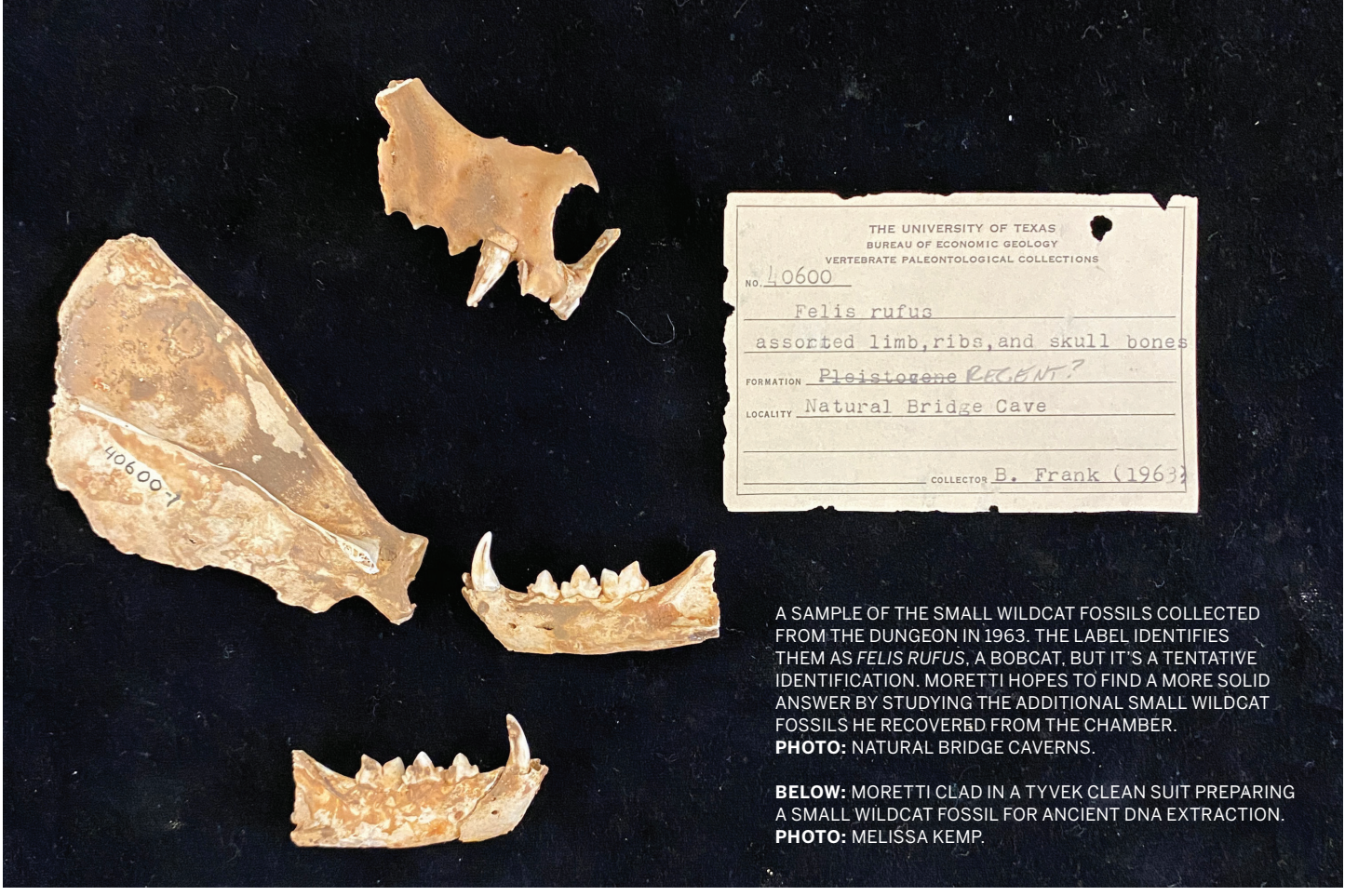
After a couple of weeks of workup, they had promising results. All three specimens retrieved by Moretti contained DNA fragments consistent with ancient DNA.

There are still a few more hoops to go through. The DNA must be confirmed as feline and not some other cave interloper or human contaminant. If it's consistent with a cat, it will then be sent for sequencing and species identification at an off-campus lab.

In the meantime, Moretti is keeping his distance from the fossils. Proximity can lead to bias when it comes to species identification, and he doesn't want a potential hunch to undermine the scientific method he is developing to analyze the bones.

The method involves creating a species scorecard of sorts that will allow him to systematically compare anatomical traits from each of the three cave cats to those from dozens of possible cat species. If a cave cat has many traits in common with a particular species, it's probably a match.

Moretti has already had success carrying out this type of analysis. In 2022, he determined that an avian ankle bone from an archaeological site in New Mexico belonged to a thick-billed parrot. In that case, he only had a single bone. The new, nearly complete wildcat specimens offer much more to work with. If successful, the ancient DNA analysis can help ground-truth



A SAMPLE OF THE SMALL WILDCAT FOSSILS COLLECTED FROM THE DUNGEON IN 1963. THE LABEL IDENTIFIES THEM AS *FELIS RUFUS*, A BOBCAT, BUT IT'S A TENTATIVE IDENTIFICATION. MORETTI HOPES TO FIND A MORE SOLID ANSWER BY STUDYING THE ADDITIONAL SMALL WILDCAT FOSSILS HE RECOVERED FROM THE CHAMBER. **PHOTO:** NATURAL BRIDGE CAVERNS.

BELOW: MORETTI CLAD IN A TYVEK CLEAN SUIT PREPARING A SMALL WILDCAT FOSSIL FOR ANCIENT DNA EXTRACTION. **PHOTO:** MELISSA KEMP.

his results, too.

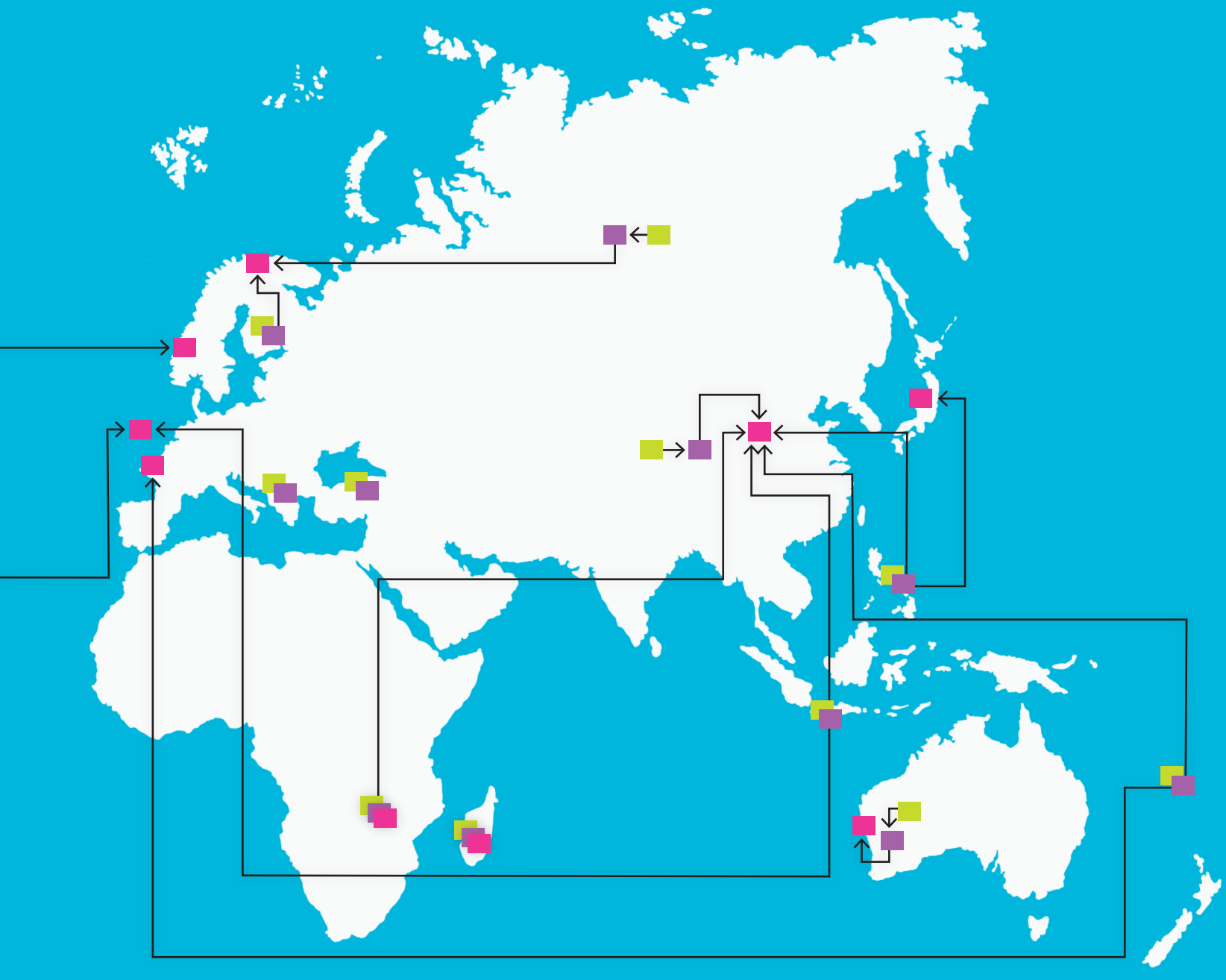
Moretti also hasn't forgotten about the muddy pawprints pressed into the passageway. He is collaborating with a lidar company on a portable system that can scan them so the exact dimensions can be compared with the foot bones from the cats. If it's a match, the mystery of how the ancient wildcats of Natural Bridge Caverns met their end could be solved.

Although Moretti is closing in on answers, the identity of the cats and the details of their deaths remain, for now, shrouded in mystery. For Moretti, he said that the journey of exploration comes with its own rewards.

"I've had to learn about ancient DNA. I've had to learn about lidar. I've had to learn about these different aspects," he said. "And it's great because it means the research is more interesting and more strongly supported. But it also means I know how to do more things too, and I can apply that to the next project and keep building those skills and learning more."

And who knows what else is waiting to be found in the depths of Natural Bridge Caverns?

THE ACTUAL COST OF ELECTRICITY



Worldwide Nickel Trade

NICKEL IS A CRITICAL INGREDIENT FOR MODERN ENERGY PRODUCTION AND PART OF THE JACKSON SCHOOL'S CRADLE-TO-GRAVE ANALYSIS OF ENERGY OPTIONS. BY TRACKING MINING, PROCESSING AND REFINING ACROSS THE WORLD, RESEARCHERS HAVE FOUND NEARLY 700 COMBINATIONS FOR PRODUCING NICKEL, EACH CARRYING ITS OWN ENVIRONMENTAL IMPACTS AND ECONOMIC COSTS.

Global Nickel Supply Chain Key

- Mine
- Processing Plant
- Refinery

MAP BASED ON DATA FROM UT RESEARCHERS

UNRAVELLING THE HIDDEN COSTS AND ENVIRONMENTAL IMPACTS OF PRODUCING ELECTRICITY — OPTION BY OPTION.

BY ANTON CAPUTO

The goal of the energy transition is simple: lower emissions and still provide enough energy for society to grow and prosper.

"It's really a matter of energy addition plus emissions reduction," said Bureau of Economic Geology Director Scott Tinker, who is considered one of the world's leading experts on energy issues. "The world needs more affordable, reliable energy—not less—to lift struggling regions from poverty. And we need to lower the emissions from all forms of energy. It 's not an easy goal, but it's achievable."

Among the issues that make the goal so complicated is that no energy source comes without downside or environmental impact.

For instance, ramping up wind and solar power and backing up these sources with batteries are highly touted strategies because, once installed, they offer carbon-free energy production.

Here's the rub though: Developing wind, solar and batteries on a large scale and replacing these facilities when they break down and degrade are going to take massive amounts of copper, nickel, cobalt, lithium and other rare earth minerals. In fact, the International Energy Agency (IEA) projects demand for these minerals will skyrocket from seven to 40 times the current rate by 2040.

And although finding and extracting these resources is possible, mining, refining and shipping them can create much carbon dioxide (CO_2), depending on where and how this occurs. There are also other significant environmental impacts on water quality, land use, biodiversity and other issues that can significantly affect local environments and communities. And all these can vary tremendously depending on a series of choices made during the process.

With this give and take in mind, Tinker and Michael Young, a senior researcher at the bureau and the associate dean for research at the Jackson School of Geosciences, have put together an interdisciplinary team of scientists, engineers and economists from the Jackson School to unravel the impact and costs – both economic and environmental – of potential energy options. The team is doing that by first conducting cradle-to-grave life cycle assessments for different electricity generation options and then working to understand how the mix of these options affects the reliability of the electric grid and the cost to consumers. These analyses cover everything from mining, processing and shipping the metals needed, to building and siting the plants, and finally to operating the facilities for 30 years.

ABOVE: (L-R) RESEARCHERS HAZAL KIRIMLI, MICHAEL YOUNG AND DAN GRAF IN FRONT OF A SOLAR ARRAY AT THE J.J. PICKLE RESEARCH CAMPUS.
PHOTO: JACKSON SCHOOL.

OPPOSITE PAGE: MICHAEL YOUNG.
PHOTO: JACKSON SCHOOL.

The goal isn't to argue for any specific energy mix, but to understand the strengths and weaknesses of each so that the overall system is made stronger, said Young, who is leading the project.

"Where I'm focused is to identify and understand the weak links in the supply chain, and by weak links, I mean from the standpoint of environmental load or environmental impact," Young said. "And if we can identify those links, we can suggest ways to reduce impacts."

Comparing Electricity Options

The program Tinker and Young created is called Comparing Electricity Options (CEO). Its goal is to move beyond a simple comparison of the options and investigate the actual impacts and costs of all forms of electricity generation.

The project is being done in stages. In Phase I, scientists are analyzing the environmental and economic impacts of five power generation options: combined cycle natural gas plants, wind with and without battery backup, and solar with and without battery backup. Other power generation options such as hydrogen and geothermal probably will be added in the future.

CEO takes a global perspective when analyzing the environmental impacts of raw materials for energy production, which can be sourced from many different areas around the world, including from Texas. But when it comes to electricity production and transmission, researchers are focusing on West Texas as the location of the potential plants in the study and the Texas grid for distributing the electricity. Narrowing the focus of this phase of research to a well-studied portion of the state and the state's self-contained electrical grid will help researchers to get their arms around the issue, Young said. But he's confident the findings will be relevant for communities and decision makers around the world.

In Phase II, the energy sources will be tested using a grid dispatch model. This model simulates the supply and demand of electricity over 15- to 60-minute increments and highlights where and when the electricity supply could run short. The reliability of the electrical grid is an important metric of success for the energy transition, and it will potentially require investments in new transmission and distribution systems and other infrastructure, Young said. The model will show how different mixes of electricity sources behave over time, and the value of batteries or other forms of energy storage, which are considered critical given the intermittent nature of wind and solar.

The final phase of CEO will involve estimating the consumer cost of electricity produced by the five options, considering environmental impact, power system costs, and the capital and operating expenses of power plants. Gürcan Gülen, a senior economist at the bureau, is leading this aspect of the study.

The idea, explained Tinker, is to find a metric relevant to the consumer to replace the current cost metric used by policymakers and others to compare various forms of electricity generation, which is called levelized cost of electricity (LCOE).

"It [LCOE] is misleading because it compares the cost at the plant gate —the panel, turbine or power plant— not the actual cost to the consumer," he said. "The actual cost requires that we consider the cost of making electricity reliable, and reliability can be expensive."

Broad Impact

The list of environmental impacts CEO scientists are looking at is quite inclusive. CO_2 emissions are certainly important, but so is air and water pollution, land and water use, and effects on biodiversity and the larger ecosystem.

Consider land use, for instance. It takes about 2,500 solar panels for 1-megawatt capacity of solar power. Scale that up to 200 megawatts – about the output of a small natural gas plant – and you are looking at a footprint on the order of 750 football fields, according to researchers on the CEO team.

This scenario is the proverbial drop in the bucket when you consider the huge growth in the number of projected solar installations around the globe

during the next few years. In 2022, the IEA projected that solar power capacity could grow by almost 1,500 gigawatts (1 gigawatt is 1,000 megawatts) in five years, surpassing coal by 2027.

For the CEO project, land use is one of about 17 environmental parameters, including particulate matter formation, ecotoxicity, acidification and others. These other impacts are local in nature and occur during mining and manufacturing stages of wind, solar and battery technologies.

The team is nearly finished with the first phase of the CEO project, which includes life cycle assessment of combined cycle natural gas, wind and solar, and nickel, lithium and cobalt, essential minerals for wind, solar and batteries. They plan to publish their results in a series of peer-reviewed publications in the near future. Results will be posted on the project's webpage at ***ceo.beg.utexas.edu***.

The Nitty Gritty

Master's students are an important part of CEO's research. Most come from the Jackson School's Energy and Earth Resources (EER) program.

Hazal Kirimli and Dan Graf are two of the seven graduate students to help with the project so far. Now an energy consultant with Rystad Energy in Houston, Kirimli tackled the life cycle assessment of nickel while she was earning her degree, with her analyses tracking the mining, processing, shipping and refining of nickel around the world.

Graf came to the EER program after working as a hydrogeologist for the

state of Wisconsin and then as a water consultant in Santiago, Chile. His work in CEO is exploring the environmental impact of siting and building different kinds of power facilities, especially how different power generation choices affect local and regional ecosystems. He is focusing on a 33-county region in West Texas about the size of Kentucky that is home to five distinct ecoregions: the Chihuahuan Desert, High Plains, Southwestern Tablelands, Central Great Plains and the Edwards Plateau.

Each power generation facility in Graf's study is modeled using life cycle assessment methods and biodiversity and ecosystem services models. The latter help determine how developing power facilities will affect the environment's natural ecosystem services. Ecosystem services, Graf said, are "basically the benefits we derive for free from nature." They include things like food, recreational benefits, climate regulation, pollination, water and air quality benefits, nutrient cycling and more.

Both Kirimli's and Graf's results showcase the staggering array of outcomes that can result at different parts of the energy production process.

For nickel alone, Kirimli came up with almost 700 scenarios that vary by the type of ore body being mined, ore grade, refining method and other factors. Environmental impact and CO_2 emissions were found to differ significantly from scenario to scenario.

In Kirimli's case, the large number of scenarios is partly a function of nickel's diverse global footprint. Unlike some commodities, the nickel trade spans the planet. Indonesia, Australia and Canada all have rich deposits, but there are mines, processing and refining facilities spread throughout the world. And dynamics can change with the development of new refining methods, price swings or even geopolitics.

Untangling the details of the global trade involved a tremendous amount of data, which she compiled by using the Ecoinvent Life Cycle Inventory Database and combing through the literature and reports from dozens of companies. She processed the data using OpenLCA software.

Further complicating the analyses, most nickel comes from two ore types: nickel sulfide, which has historically provided most of the world's nickel; and laterite, which has become more common in recent years as the ore grade of sulfide deposits has diminished. Laterite is closer to ground surface and tends to contain more water, which makes it more difficult to process after mining.

In addition to ore type and mining and processing locations, she tracked refinery locations and the numerous technologies used to process the ore. These varied greatly and depended on the end product desired, which can be nickel metal or ferronickel (an alloy of nickel and iron), both of which are used in stainless steel production, or nickel sulfate, which is used to make lithium-ion batteries.

"It's really hard to generalize the process for nickel production, and I realized after months that when we saw a nickel number in the literature, it doesn't tell the exact picture, because there are so many variables," she said.

So, for each one of those 700 scenarios, Kirimli worked to uncover the details of environmental impacts. This translates to many findings, with layers to each.

For instance, when simply comparing ore types, sulfides versus laterites, she found that the average CO_2 output is three times as high for laterites as for sulfides. She also calculated averages for 14 other environmental impacts, ranging from fine particulate matter pollution to marine ecotoxicity, a measure of the chemicals and other pollutants added to the marine environment.

But those are just averages by ore type. From there, she calculated the impact of all combinations of ore types, mining, processing and refining throughout the world. This went beyond nickel itself and considered the generation mix of the electrical grid where the facilities were located. Her findings, not surprisingly, are encapsulated in a massive spreadsheet and will be published in a peer-reviewed journal soon. (You can find a preliminary list of key findings in the box on page 46.)

After two years of crunching the numbers, one message Kirimli came away with was how important the ore grade is to limiting climate change and overall environmental impact. This poses a fundamental challenge, she said, because the unavoidable trend in mining operations is toward lower-grade ore.

"If we don't find ways to make our operations more efficient or look for other ways to reduce our emissions, we are going to go the wrong way," she said.

Graf's results paint a similarly complex picture of the tradeoffs that come with different modes of energy development. For example, generating electricity with solar and wind can offer significant reductions in air pollution impacts and as much as a 97% reduction in CO_2 emissions over the lifetime of a project. But the processing of metals needed to build these renewable sources of energy may create up to 67 times as much water pollution as those used for combined cycle natural gas turbine plants. At the same time, the amount of water needed to operate a combined cycle natural gas plant can be nearly 100 times as much as wind and solar. Findings such as these are intended to help engineers and policymakers focus on how to minimize the impact of each energy source by, for example, finding cleaner ways of manufacturing metals or finding ways to minimize their impact on water.

The area Graf studied, which includes the Permian Basin, already contains significant energy development on the order of about 180,000 oil and gas wells and 105 utility-scale combined cycle gas, wind and solar facilities. Combining wind and solar with batteries for backup yields the five different types of power generation facilities that were examined by the CEO project, with each generation technology producing an average of 3 terawatt-hours per year over a 30-year lifespan. In each case, Graf is examining the intersection of the facility with the different ecoregions and assessing the local impacts to those ecosystems.

"We have done 500 simulations, and we will probably do over 1,000

by the time we are done," he said. "We're finding that location matters. Particularly when looking at ecosystem services, we're finding that small changes in location can have a big impact on the environment."

For example, installing energy infrastructure on previously disturbed lands has less impact on ecosystems than installing on pristine lands. Overlaying land use layers (from geographic information system technology, or GIS) onto energy infrastructure is allowing Graf to quickly see where impacts could be higher.

Looking Ahead

The CEO project is still working on crunching the numbers. Findings will be released as stand-alone studies and posted on the project website during the next few years. The goal is to offer decision makers the tools to make global energy and emissions decisions with as little impact to the environment and surrounding communities as possible. Young emphasized that this could be especially important to communities in developing countries that frequently bear the brunt of global energy and resource development, often without directly benefitting themselves.

"There is a growing movement to make sure that the energy transition and all of these processes are not going to create really huge environmental damage and health impacts on the communities that the rest of the Western world, for the most part, are relying on," he said.

When it comes to climate change, CO_2 is among the most critical parameters. The study is showing complexity here, too. The projected development of solar and wind is going to initially spike CO_2 emissions, Young said. Eventually, once the facilities are running, the carbon-free energy produced will reduce the carbon intensity of the electricity sector and result in lower CO_2 emissions to the atmosphere. But exactly when this occurs will depend on the choices made for how and where the raw materials are mined, processed, shipped and refined.

"We expect a crossover point on carbon emissions at some point in time, but how long does that take?" Young said. "Is it 10 years, 20 years? That depends on a lot of different assumptions. We are being very open with these so that other people can understand the context of the study and replicate what we're doing."

All this is important to keep in mind as the energy transition progresses. It's a necessary transition, but it's not straightforward.

"The scale of the resources needed is enormous and unprecedented," said Jackson School Dean Claudia Mora. "That's why this project is so important. When you look at the complete life cycle of all energy options, there is no free lunch. It is critical that we understand the options and the impact of each choice."

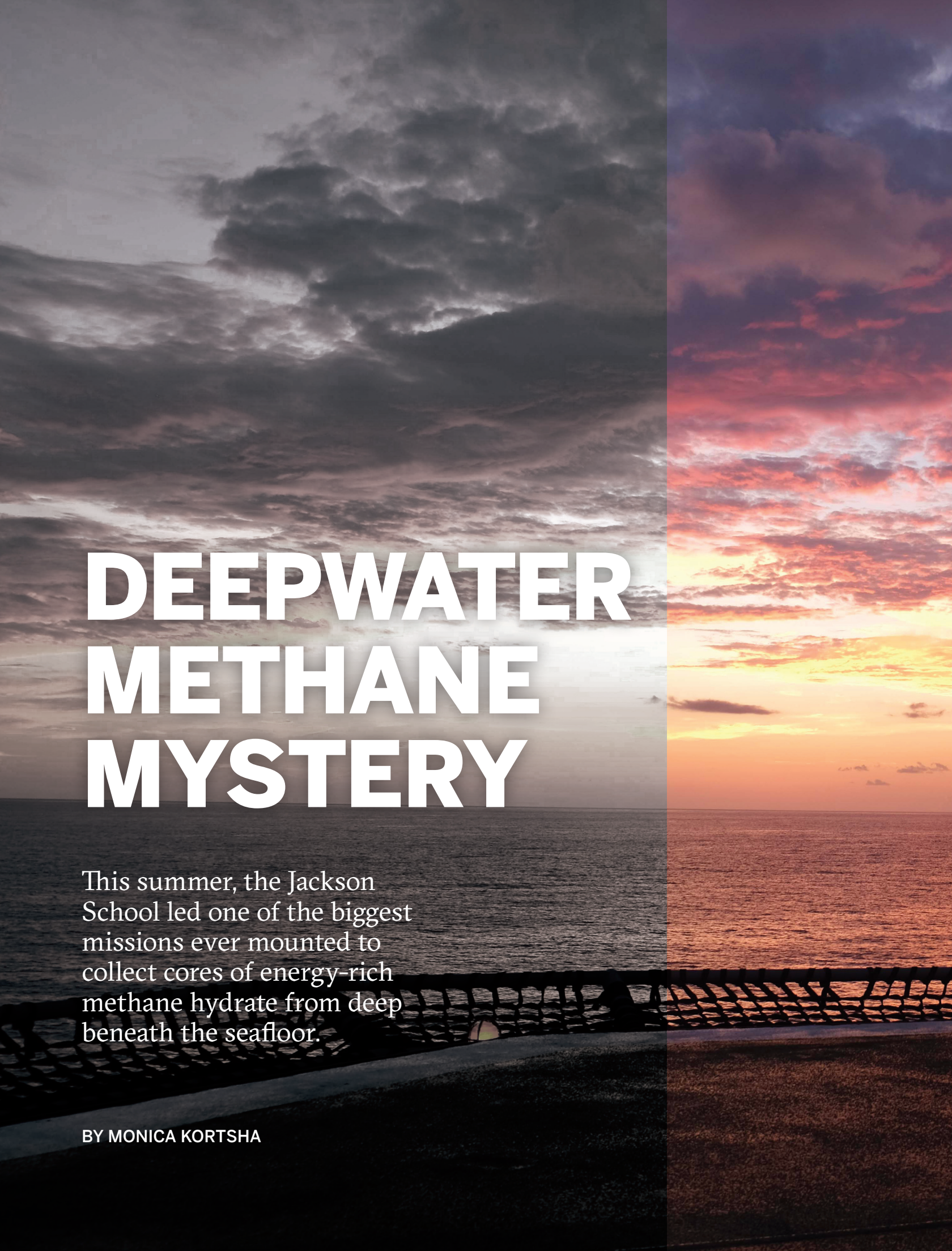
ABOVE: CHEMETALL FOOTE LITHIUM OPERATION IN ESMERALDA COUNTY, NEVADA. **PHOTO:** DOC SEARLS/FLICKR.

Environmental Impacts of the Global Nickel Industry

Hazal Kirimli, who recently earned a master's degree from the Jackson School of Geosciences Energy and Earth Resources program, spent two years looking at the environmental impact of the worldwide nickel industry. Her cradle-to-grave analysis examined nearly 700 global combinations of mining, processing, refining and shipping nickel.

Her complete finding will be published in a peer-reviewed journal in the near future. Preliminary results include these key points:

- The impacts of nickel production from laterite ore, which now accounts for two-thirds of global primary production are up to 13 times as high as those of sulfides in 11 out of 16 impact categories.
- As ore grade decreases, emissions of all types increase nonlinearly. For example, the energy requirement of traditional mining, processing and refining equipment (which are mostly diesel-powered) increase by up to 18-fold. Similarly, land use increases almost 25-fold as ore grade quality decreases from excellent to poor.
- Pyrometallurgy (melting ore) used for ore processing is the most emission-intensive route for most of the environmental impacts studied. Hydrometallurgy (leaching ore), though requiring more land, is less emission intensive.
- Meeting future demand with recycled nickel may reduce CO_2 emissions of stainless-steel production significantly. Other environmental impacts could also be reduced, as well as reliance on unpredictable global supply routes.



DEEPWATER METHANE MYSTERY

This summer, the Jackson School led one of the biggest missions ever mounted to collect cores of energy-rich methane hydrate from deep beneath the seafloor.

BY MONICA KORTSHA

MISSION SCIENTIST EVAN SOLOMON WATCHES THE SUNSET FROM THE HELIPORT OF THE Q4000, THE ENERGY PLATFORM THAT SERVED AS A SCIENTIFIC DRILLING VESSEL DURING THE METHANE HYDRATE CORING MISSION.
PHOTO: PETER FLEMINGS.

The middle of the Gulf of Mexico is a busier place than you might think. Its deep-blue waters are dotted with passing boats and energy platforms. This summer, the Q4000 was one of them.

In late July, the platform settled over a spot called Walker Ridge, about 150 miles off the coast of Louisiana, where the continental shelf starts to slope into the deep ocean. A bright yellow flag flying on deck announced who sent it there: UT—as in The University of Texas at Austin.

Most of the time, the Q4000 is an industry rig. It has two remotely operated vehicles (ROVs) for inspecting and servicing wellheads, and observing boreholes on the ocean floor. A wall of shiny plaques in the vessel's common room commemorates the rig's role in capping the Deepwater Horizon oil spill.

This summer, UT Austin outfitted Q4000 to new ends. The rig was turned into a scientific drilling vessel, one that could take core samples of methane hydrate—a super-compressed form of gas trapped inside a cage of water ice, and one of the largest caches of carbon on the planet.

Walker Ridge is just one of many methane hydrate reservoirs found under the seafloor of the Gulf, and around the world. Deposits of the mysterious substance also form beneath ice sheets and Arctic permafrost. Scientists estimate that, collectively, the global supply of hydrates may hold anywhere from 5% to 22% of the Earth's mobile carbon – the carbon that plays the most immediate role in shaping climate, environment and life on Earth. For comparison, that is up to 10 times as much carbon as what's in the atmosphere.

There are big questions about how methane hydrate may shape the energy landscape, with undersea reservoirs potentially holding an untapped supply of natural gas, particularly for energy-poor countries. The solid hydrate is incredibly energy-dense, with each unit of methane hydrate having 165 times the energy of an equivalent volume of gas at surface conditions.

But methane is also a potent greenhouse gas, with emissions that have about 25 times the heat-trapping potential of carbon dioxide. There are big questions here, too, about what conditions may lead the methane to escape from its hydrate cage and seep into the wider world—and the impacts this could have on the environment and climate.

Answering those questions requires getting an up-close look at a methane hydrate reservoir from top to bottom. That's exactly what the scientific coring mission is seeking to do, according to Jackson School of Geosciences Professor Peter Flemings, the chief scientist on the mission, called UT-GOM2-2.

"One of the amazing things about the University of Texas is that if you say you want to do something really big, they will help you find a way to make it happen," said Flemings. "There's no bigger example I can think of than this."

Joining Flemings offshore is a team of scientific collaborators from four other universities, the U.S. Geological Survey (USGS), and engineering company Geotek Coring. That's not to mention the 108 additional crew members—the

cooks, cleaners, drillers, and more—providing support so the mission can run 24 hours a day for a month straight.

A mission of this scope and scale is complicated and expensive. Offshore rigs don't come cheap; it costs half a million dollars a day to keep the Q4000 running. The mission is made possible by a grant of more than $100 million from the U.S. Department of Energy, one of the largest ever awarded to a university. It reflects the importance of methane hydrate—and how much there is to discover about the mysterious, energy-rich substance at the bottom of the sea.

ARRIVAL

It's about 11:30 p.m. on a warm summer night. A team of scientists working the night shift has gathered on the deck of the rig to watch the latest core sample come in.

Clad in white hard hats, safety glasses and blue coveralls, the scientists tilt their heads toward the sky. The core may come from the depths, but it's currently lifted in the air, encased in a 29-foot-long drill pipe and carried by a crane.

A team of drillers stabilizes the pipe with ropes as the pipe glides across the deck and is lowered into a cradle that's set up a few feet away from the science team.

The scientists keep a safe distance as the drillers prepare to open the pipe. The container is known to spew seawater and sediment as it's opened.

Among the science team on deck this evening is Flemings. He watches closely as the drillers work to free the core sample that's inside.

A Holistic Look

This summer isn't the first time Flemings has watched core arrive on the Q4000. In 2017, he led UT-GOM-1, a mission aboard the vessel that extracted the first pressure cores of methane hydrate from the Gulf of Mexico.

The mission, which was funded by the same Department of Energy grant as the current mission, sampled a single reservoir layer about 1,300 feet below the seafloor and successfully retrieved 13 pressure cores that were shipped to a specialized lab at the Jackson School for storage and study.

It's impossible to keep methane hydrate intact unless it's kept under pressure. If the pressure lessens, the methane escapes, bubbling away. While the cores provided valuable scientific samples, the more important accomplishment, said Flemings, was that it proved that the pressure-coring tool worked.

This success opened the door to a bigger science mission—one that could sample an entire methane hydrate reservoir. Flemings and the science team set their sights on taking cores—both pressurized and conventional—that spanned from the bottom of the seafloor to more than 3,000 feet below it.

"UT-GOM2-1 was a technology test," said Flemings. "The true science, in terms of a systems understanding of the reservoir, will come from UT-GOM2-2."

The 24-member, offshore science team includes a wide range of perspectives. There are sedimentologists, microbiologists, geochemists and other cross-disciplinary experts on the team. And while they each come with their own questions about the core and ways of sampling it, the mission plan calls for them to combine what they learn into a wholistic understanding of the Walker Ridge reservoir, and an improved understand of methane hydrate in general.

The scientists aboard also have a range of experiences with the stuff.

Ann Cook and Tim Collett were both a part of a 2009 mission to the Walker Ridge reservoir that drilled two boreholes and collected well log data, which now serves as a guide to where the methane-hydrate-rich layers are located. Cook was a graduate student at the time. Now, 14 years later, she is returning to the reservoir as a full professor at The Ohio State University and the director of undergraduate studies at its School of Earth Sciences.

"I feel so lucky to be here again," she said.

Collett was then and still is a researcher with the USGS. He is the mission's general go-to guy for any question about methane hydrate, big or small. He can tell you the location of the

OPPOSITE PAGE, TOP: PETER FLEMINGS GIVES A "HOOK 'EM" FROM THE DECK OF THE Q4000.
OPPOSITE PAGE, BOTTOM: THE OPERATIONS FLAG IDENTIFIES THE VESSEL'S LOCATION AND OPERATOR. THE "UT" STANDS FOR THE UNIVERSITY OF TEXAS AT AUSTIN.

LEFT: FLEMINGS AND TIM COLLETT OF THE U.S. GEOLOGICAL SURVEY WATCH A CORE SAMPLE ARRIVE ON DECK WHILE WORKING THE NIGHT SHIFT.

PHOTOS: JACKSON SCHOOL.

coring tool in the drill string, or trace the arc of methane hydrate research stretching back to the 1980s. "Ask Tim" is a common refrain heard around the ship to a range of questions.

The team also includes graduate students and postdoctoral researchers who are new to the world of hydrate research, but who have been recruited by their advisers to lend their research skills. For example, Kelly Shannon, a microbiology graduate student at Oregon State University, is helping search for signs of deep-sea microbes in the core samples by applying DNA sampling and sequencing techniques he has honed studying river microbes in salmon runs.

The mission's sole undergraduate researcher is Camila Van Der Maal, a first-year geophysics student at the Jackson School. Van Der Maal started working in Flemings' core lab this spring, degassing pressure cores from the 2017 mission. On this summer's mission she is working with Shannon and Rick Colwell, a microbiologist and professor at Oregon State, collecting microbiology samples.

Microbiology is new to her, but that can be said about much of this mission. She had never traveled to another state in the U.S. before this mission, let alone taken a helicopter to a rig to conduct science at sea.

"It's kind of a shock to be here," she said. "I thought I would need a lot more experience."

But Flemings said she was ready.

"One of the most exciting things I do as an educator is to just give students an opportunity to flourish," he said. "Ultimately, Camila is a capable person."

INTAKE

The core that arrived on deck is free, thanks to some vigorous hopping and a large pipe wrench wielded by a Geotek technician.

It's a conventional core—meaning that it's not pressurized —from about 200 feet below the seafloor. Reaching these depths involves deploying a string of drill pipes from the drill floor of the vessel into the seafloor. Once the string reaches its target depth, the coring tool is sent down the pipes to collect a sample.

For pressure samples, this is a delicate operation. To maintain pressure, a ball valve has to close at just the right moment before the core is pulled back to the surface. For conventional cores, it's a bit more straightforward. In the words of Junior, a Geotek technician: "You smash it in, smash it up, smash it out."

> **"CORE CAN HELP CONFIRM SCIENCE OR REFUTE IT... THERE'S ALWAYS SOMETHING THAT WE PULL UP IN A NEW CORE THAT IS FUN OR EXCITING."**
>
> **-EVAN SOLOMON**

The gray seafloor sediments that make up the core are contained in a clear plastic lining. The drillers pull the core from the pipe and carry it to the core receiving lab—the first stop for all conventional core once it leaves the drilling floor. (The pressure core goes to a different facility for X-ray scanning.)

The lab is in a white shipping container. The drillers insert the core through a small hole cut directly into the container's side. Awaiting it on the other side are Collett and Peter Schultheiss, the owner of Geotek. They pull the sample in until it disappears from the outside.

The core has officially left the world of drilling. It's a scientific specimen now.

Science Questions

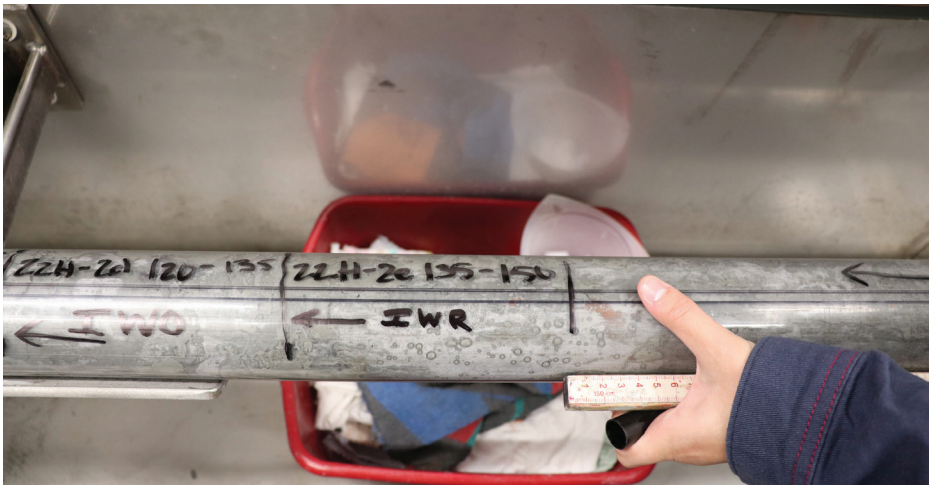
The pressure cores collected during the 2017 mission provided the first chance to study samples of intact methane hydrate from the Gulf of Mexico in the lab. They've been the subject of dozens of research papers, including a special bulletin of the American Association of Petroleum Geologists.

According to Flemings, there are two major findings that have come from studying the pressure cores that are guiding the science on this summer's mission.

The first finding: the 2017 cores were absolutely packed with methane hydrate. The research revealed that 79% to 93% of the pore space between the sand grains in the pressure cores was filled with the frozen gas.

However, despite the high hydrate concentration, it's unknown where in the subsurface the methane originally came from and how old it is. A major focus of the science team is sampling the gas and pore water in the cores for geochemical clues that can help answer this question for Walker Ridge.

Rachel Coyte, a postdoctoral researcher at The Ohio State University,



brought a supply of thin metal tubes for capturing noble gases that can help determine the age of the hydrates captured in the pressure cores. And Evan Solomon, a professor and geochemist at the University of Washington, is collecting pore water by squeezing it from hockey-puck-size samples cut from the core in a large hydraulic press and preserving its chemical constituents so they remain in the same state as they were in the reservoir.

"These chemicals can show the source depth of where the methane came from, where it originated and how it gets into the reservoir," Solomon said.

The second significant finding from the 2017 cores is that microbes were responsible for making the methane from which the hydrates form. Flemings said this discovery came as a bit of a surprise. The oil and gas deposits in the Gulf of Mexico are the result of thermogenic processes—the slow crushing and heating of dead organic material as it's piled under tons of sediment over eons.

It was presumed that the methane found in Gulf hydrate would originate from the same processes. But based on the 2017 cores, the methane isn't produced by the gradual crushing of dead matter but as a byproduct of life in action—generated by microbial metabolism of organic carbon.

The scientists discovered that the methane came from microbes by identifying an isotopic signature in the gas. But for this mission, they're hoping to find specific microbes that call Walker Ridge home—and to investigate the role they play in both producing methane and consuming it.

Methane-eating microbes—which have been studied in other methane-rich areas of the seafloor—are important for understanding environmental questions about methane hydrate, said Colwell, the microbiology lead, because their microbe-munching

OPPOSITE PAGE, BOTH PHOTOS: CORING TECHNICIANS FROM GEOTEK PUSH A CONVENTIONAL CORE SAMPLE INTO THE RECEIVING LAB AS SCIENCE TEAM MEMBERS TIM COLLETT AND PETER SCHULTHEISS PULL IT INTO PLACE FROM THE INSIDE.

ABOVE, CLOCKWISE FROM TOP RIGHT: STEPHEN PHILLIPS OF THE U.S. GEOLOGICAL SURVEY DEGASSING PRESSURE CORE SAMPLES TO DETERMINE HOW MUCH METHANE GAS THEY HOLD; A CONVENTIONAL CORE IN THE CORE RECEIVING LAB. THE CORE LINER IS MARKED UP INTO SUBSAMPLES FOR FURTHER STUDY AND PROCESSING; A COLLECTION OF GLASS VIALS CONTAINING SEDIMENT SAMPLES FROM THE CORE; A CORE SAMPLE ARRIVES ON THE DRILL DECK.

PHOTOS: JACKSON SCHOOL.

ways create a natural environmental filter that keeps large amounts of methane from escaping into the ocean and atmosphere.

"Trying to understand these things is really important to unraveling these hydrate problems," Colwell said.

CURATION

Still encased in its liner, the core lies over a metal trough in the core intake lab. An automatic thermal imaging device rolls over it, capturing hidden pockets of methane, and possibly lingering remains of hydrate that may be inside.

Methane gas is found throughout the reservoir system to different degrees. Whether it's free gas or frozen hydrate is a matter of temperature, pressure, and pore space for the hydrate to fill. The science team is tracking the methane concentration as they drill deeper and deeper down by taking gas samples from each core that surfaces.

The gas collects in large air pockets interspersed throughout the core called voids. Camille Sullivan, a graduate student at the University of New Hampshire, pushes a syringe through the liner into one of these voids and pulls the plunger, inflating a small silver bag with a sample of methane.

Voids form during the core's journey to the surface as the gas inside the sediments expand and escape under the reduced pressure. They're a reminder of how the core is acclimating to its new surface conditions. While the pressure cores are preserved as they were in the reservoir, the more time the conventional cores spend on deck, the less they resemble the seafloor. The gas leaves. The microbes mingle. The scientists must work quickly to take samples before they change too much.

Cook marks the core lining with a permanent marker—flagging voids for sampling and portions to be sent off to the other labs, housed in smaller shipping containers on deck, arranged in a manner that Cook describes as a "jigsaw puzzle trailer park." But most of the core is left untouched. It will be split and analyzed during the onshore portion of the mission happening in Salt Lake City after the conclusion of the offshore portion of the mission. This second phase of the mission will draw about a dozen additional collaborating scientists from around the world, eager to see what the cores contain and collect samples that could help advance their own methane hydrate research.

Early Discoveries

Even though the offshore sampling is providing only a cursory look inside the core samples compared with what will happen onshore, the science team has still found some tantalizing clues that offer a glimpse of the inner workings and history of the methane hydrate reservoir below.

Solomon has found streaks of black iron sulfide in a core sample that might mark the past location of the layer of methane-consuming microbes. He also found a sign of where they might exist today in the form of a fingernail-size clump of pink slime, which Colwell was particularly excited about. The slime served as a good sign that there would be rich microbial communities to sample near the top of the reservoir.

Joel Johnson, a sedimentologist and professor at the University of New Hampshire, is also excited about an X-ray from the pressure core lab. The X-ray image showed a core composed of perfect stripes of millimeter-wide layers of sediment. Its pristine appearance could indicate that the sediment was deposited at a time when the bottom of the ocean was anoxic and unable to support abundant sea life, like clams and worms, which usually leave their mark in sediment cores in the form of burrows. This low-oxygen environment could have also produced some of the black iron sulfide that Solomon spotted.

"Core can help confirm science or refute it," Solomon said. "There's always something that we pull up in a new core that is fun or exciting."

Alejandro Cardona, a research associate at the Jackson School, said that it's inspiring to see new core samples just about every day.

"On land, when you see a rock, it's something that perhaps many other people have seen before," he said. "However, out here, we're accessing a location that's 2 kilometers deep in the water, and we are the first to see these cores."

Mission progress and findings are discussed at daily science meetings run by Flemings and Collett. But informal discussions are happening between scientists all the time—over hearty

ABOVE: SCIENCE TEAM LEADERS JOEL JOHNSON AND ANN COOK CURATING A CONVENTIONAL CORE IN THE CORE RECEIVING LAB.
PHOTO: JACKSON SCHOOL.

meals, while lacing up steel-toed boots, or taking a moment to watch stunning sunsets and schools of flying fish glide over the waves.

For Van Der Maal, these discussions have offered critical insight into the institutional side of science—the stuff that isn't covered in class but that is nevertheless essential to know, from how to find grants and what they cover, to summer research opportunities. At the same time, the team is making sure she is keeping up with the basic science of the mission, too.

During their first week at sea, Flemings had her create a chart plotting methane hydrate stability, the temperature and pressure conditions under which hydrate forms and dissolves. Jackson School graduate student Zachary Murphy gave her two assignments on methane hydrate physics pulled from a graduate-level course. The assignments proudly hang on the rig's office minifridge, both marked with a bright red A+.

"She will never forget what the hydrate stability barrier is, solving these problems out here," Flemings said.

However, Van Der Maal almost wasn't part of the mission—or part of the Jackson School.

While finishing high school remotely during the pandemic, Van Der Maal said she became burned out by college preparation classes and was having second thoughts about going to college at all. That changed after she learned about the scientific cruises led by researchers at the Jackson School's Institute for Geophysics. She had dreams of going on a scientific mission to Antarctica. She decided to apply to the Jackson School in hopes of working her way onto one.

Although the Gulf of Mexico isn't exactly the South Pole, she said the methane hydrate mission provides exactly the challenge and adventure that her dream of Antarctic cruises inspired. In her downtime, she has been working with Cook on a project proposal that can hopefully land her a spot on an upcoming scientific drilling mission happening in New England next year.

"I've learned so much from everyone out here," she said. "I can't wait to get back offshore."

Physical Science

Once the core is on deck, sampling follows a scientific protocol, set in place by the science team months in advance. But when it comes to extracting the core, it's a matter of responding to on-the-ground conditions. The swell of the sea bends the drill string, affecting drilling depth and the angle the pipes enter into the reservoir. The sticky subsurface sediments often grip the coring tool and won't let go without a fight.

Flemings and Thomas "TR" Redd, the vessel's "company man," who serves as a liaison between the science team and the drillers, are often working out how to overcome coring problems in the moment. The two frequently can be spotted heading back and forth between the rig office and the "dog house," the control room for drilling machinery located just behind the drilling floor.

"Taking core is a mechanical effort," Flemings said one afternoon, standing near the drilling floor as drillers pulled a pipe containing the coring tool from the deck. "There are no automated locks or robots to put pipe into position. It's human labor and heavy machinery."

For the first week of the mission, the team overcame all the coring curve balls and hurdles. The drilling and coring progressed. But at about 500 feet down, operations suddenly came to a standstill.

An essential piece of coring equipment, the fan motor on the top drive, had broken down. That same day, the vessel's captain announced that cases of COVID-19 had sent a couple of members of the science team and the drill team into quarantine.

The mission would continue. They would just have to wait out repairs and COVID-19 cases.

"It's a pendulum situation right now," Flemings said. "We'll see how it goes and deal with it."

In an age of digital models and automatic algorithms, this mission illustrates how pioneering science about the planet is still very much a physical process. There is no other way to get methane hydrate cores than to drill thousands of feet below the seafloor. When obstacles arise, the only way out is through.

In the midst of these issues, Flemings sent an email to the offshore science party, emphasizing the difficulty of their mission, the challenges they have overcome so far, and all they have left to do.

"Be patient...we will get there," he wrote. "You are doing great things. I am proud to be here with you."

A couple of days later, the cores were coming up the drill string again. The journey into the depths of the reservoir continued on, as the scientific discoveries it produces will—for years to come.

LEFT: CAMILA VAN DER MAAL, AN UNDERGRADUATE FIRST-YEAR GEOPHYSICS STUDENT AT THE JACKSON SCHOOL AND MEMBER OF THE OFFSHORE SCIENCE TEAM. **PHOTO:** JACKSON SCHOOL.

MORE METHANE HYDRATE

Read the Mission Blog
www.jsg.utexas.edu/news/tag/gom2-blog/

Watch a Short Documentary on the Mission
youtube.com/JSGUTAUSTIN

Collaborating With Neighborhoods on Climate Change Resilience

Researchers at The University of Texas at Austin are partnering with local community groups to help make underserved East Austin neighborhoods more resilient in the face of climate change and issues related to urban growth.

The new five-year project is led by the Jackson School of Geosciences Environmental Science Institute (ESI) with help from local community groups such as People Organized in Defense of Earth and Her Resources (PODER). The goal of the collaboration is to bring researchers together with neighborhood residents and organizations who can best define community needs, said ESI Director Jay Banner.

"All too often, I think, outreach from science communities is: 'We've come up with these research results, and here they are. Go figure out how you can best use them,'" he said. "But equally important is the expertise and knowledge base of members of the community and community organizations that know best what their community needs."

The $7 million effort, funded by the National Science Foundation, is called Community Resilience Integrated into an Earth System Science Learning Ecosystem (CRESSLE). It involves experts from throughout UT and research in three general categories: water resources, climate resilience, and communities and landscapes.

In addition to tackling problems facing local communities, a goal of CRESSLE is to help build connections between geoscientists and diverse community groups, and vice versa. Each of the three research cohorts will include graduate students and a postdoctoral fellow, as well as faculty researchers.

ABOVE: EAST AUSTIN MURAL.
PHOTO: JIM NIX.

Texas Science Museum Reopens

After closing its doors in 2022, the Texas Memorial Museum is back.

Now called the Texas Science & Natural History Museum, the museum located on campus at The University of Texas at Austin reopened to the public in September and includes new exhibits alongside old favorites.

Many of the specimens and research on display have a close connection to the Jackson School of Geosciences. This includes a display on dinosaur sound that features Professor Julia Clarke and a new model skeleton of *Tyrannosaruus rex* in the museum's Great Hall that is based on bones held in the Jackson School's vertebrate paleontology collections. The T. rex joins the model *Quetzalcoatlus northropi*, a pterosaur and long-time resident of the museum that hangs from the ceiling. The pterosaur species was discovered in 1971 by UT geology graduate student Douglas Lawson.

For more information, go to ***www.sciencemuseum.utexas.edu***.

Jackson School Spotlights Scientists in New Publication

This spring, the Jackson School of Geosciences launched The Geoscientist, a publication that highlights the world-class research happening at the Jackson School—and the people who do it.

Esti Ukar, a research scientist at the Bureau of Economic Geology, is on the cover of the first issue. The publication features a Q&A with Ukar about her research on net-zero mining methods that could help store emissions while extracting critical minerals. The Q&A is reprinted in the Newsletter. Read it on page 19.

The fall issue is out now. Read The Geoscientist online at ***www.jsg.utexas.edu/news/the-geoscientist***.

ABOVE: THE COVER OF THE FIRST ISSUE OF THE GEOSCIENTIST.
PHOTO: JACKSON SCHOOL.

Bureau Staff Goes to School for "Geology Day"

In April, staff members and researchers from the Bureau of Economic Geology wowed students at Thornton Elementary School in Temple with fossils, model volcanoes and other geosciences-themed demonstrations.

The presenters included the bureau's Amanda Calle, Lucy Phlegar, Linda Ruiz McCall, Zhicheng "William" Wang and Carson Werner. The event was attended by about 250 fourth grade students and 11 teachers.

According to McCall, the students and teachers said that is was "as if the museum came to the school."

The bureau is raising funds for more geology outreach. Donations can be made at ***give.utexas.edu/?menu=OGPBEG***. Please list "Geology Day Outreach" in the comments.

ABOVE: POSTDOCTORAL FELLOW ZHICHENG "WILLIAM" WANG TEACHES STUDENTS ABOUT CARBON DIOXIDE.
PHOTO: BUREAU OF ECONOMIC GEOLOGY.

Tisato Shares World of Seismology at Elementary School Talk

Nicola Tisato, an assistant professor in the Department of Earth and Planetary Sciences, paid a visit to Austin's Reilly Elementary on May 16, 2023, to give a presentation about earthquakes to the school's third and fourth graders.

Shengshui Yun, who teaches third and fourth grade Mandarin, math and science, said that the students enjoyed learning from Tisato and seeing an earthquake experiment in action.

"[The students] are little scientists who are full of curiosity and a passion for science," he said. "The informative and enjoyable presentation captivated the kids...it was a truly wonderful experience for us all."

ABOVE: ASSISTANT PROFESSOR NICOLA TISATO PRESENTS TO AN AUDIENCE OF STUDENTS AT REILLY ELEMENTARY.
PHOTO: NICOLA TISATO.

Boerne Gets Water Data Dashboard

With help from researchers from the Bureau of Economic Geology, the City of Boerne recently launched an interactive water dashboard that allows anyone to access a range of water data in one place.

Bureau Senior Research Scientist Michael Young and Vianey Rueda, an alumna of the Jackson School of Geosciences Energy and Earth Resources master's program, played lead roles in creating the dashboard. The project was informed by "Internet of Water" principles, which recognize the importance of using modern data infrastructure to effectively manage water resources and making water data accessible to the public.

For the past several years, Young and Rueda, along with collaborators at Duke University and Boerne's Cibolo Center for Conservation, have been working with the City of Boerne to make the dashboard a reality. The project was partially funded by the Cynthia and George Mitchell Foundation.

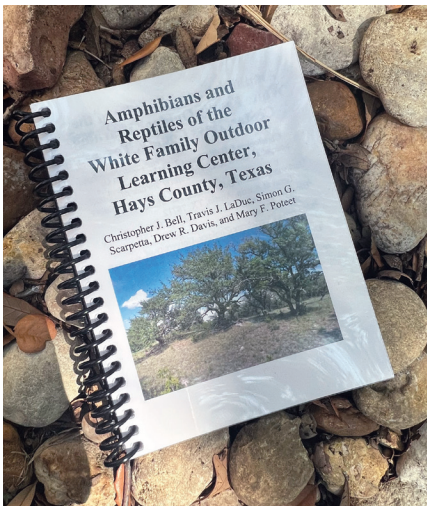
"We were excited to work with the City of Boerne on this project," said Young. "With their support, we were able to develop an effective tool that can promote better stewardship of water resources and greater resilience during droughts or other water-supply challenges."

The dashboard includes data on groundwater and surface water supplies, water demand, and water reuse, among other water data. The information is displayed on the dashboard through graphs, charts, maps and other illustrations that provide users with a visual understanding of both current and historical water data.

In addition to serving the Boerne community, the researchers said the dashboard also serves as a proof-of-concept tool that could be mirrored by other communities interested in creating their own regional water data programs.

Visit the dashboard at ***www.ci.boerne.tx.us/149/utilities***.

Books



Amphibians and Reptiles of the White Family Outdoor Learning Center, Hays County, Texas,

By Christopher Bell, Travis LaDuc, Simon Scarpetta, Drew Davis and Mary Poteet

The 266 acres that make up the White Family Outdoor Learning Center is an outdoor classroom and living laboratory for students and researchers at the Jackson School of Geosciences.

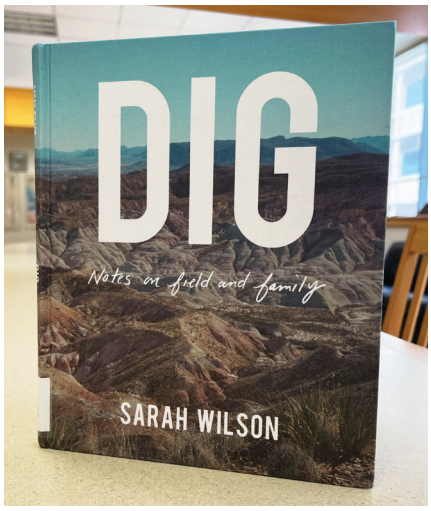
But more than geoscientists are at the learning center.

A new self-published book by the Jackson School's Christopher Bell, a professor in the Department of Earth and Planetary Sciences, and collaborators provides an overview of the reptiles and amphibians that call the learning center home.

The book contains 35 entries. Each entry includes a photo, a brief description, and whether the animal has been spotted at the center or is just suspected of being there.

Cataloging the ecological diversity of the learning center is an ongoing project. The book includes a QR code to the center's iNaturalist webpage, where visitors can upload photos and data on the plant and animal life they have encountered at the learning center.

The book is available to visitors of the learning center for free. Contact the Jackson School's communications office for more information.



DIG: Notes on Field and Family

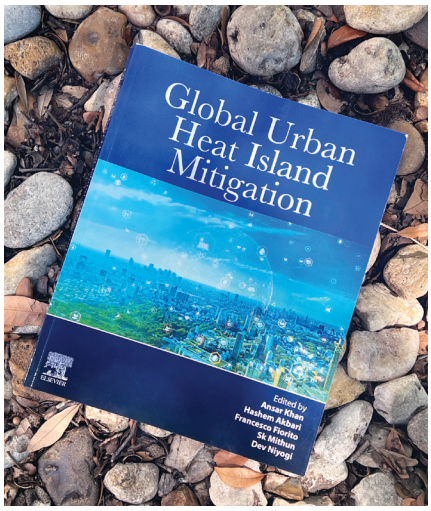
Photographs by Sarah Wilson. Essay by Matthew Brown.

West Texas vistas, fossil digs at Big Bend National Park, and dramatic specimens from the Vertebrate Paleontology Laboratory are all featured in a new book of photographs by Sarah Wilson.

Wilson is the granddaughter of John "Jack" Wilson, who founded the Vertebrate Paleontology Laboratory in 1949. In her book, Wilson uses photography to explore family connections and to create self-portraits in the style of geologic and anatomical charts.

The book also features an essay by Matthew Brown, the current director of the Vertebrate Paleontology Laboratory.

The book is available at ***www.yoffypress.com/catalog/dig***



Global Urban Heat Island Mitigation

Edited by Ansar Khan, Hashem Akbari, Francesco Fiorito, Sk Mithun and Dev Niyogi

Around the world, communities are facing rising temperatures. A recently published book offers an overview of the issue and potential technologies and strategies for relief. The book is co-edited by Dev Niyogi, a professor in the Jackson School of Geosciences Department of Earth and Planetary Sciences.

The book combines urban climate research concepts with case studies. Examples include quantifying shade levels and tree planting, the role of lighting in urban heat island mitigation, and the influence of land use composition and pattern on land surface temperature.

The book's intended readership is urban planners and designers, climatologists and city policy makers.

The book is available through Elsevier: ***shop.elsevier.com/books/global-urban-heat-island-mitigation/khan/978-0-323-85539-6***

Hot Science — Cool Talks

This spring, "Hot Science—Cool Talks" returned to in-person events after two years of remote programming. The popular speaker series invited two members of the Jackson School of Geosciences to share their research in an all-ages talk with the wider Austin community.

Assistant Professor Geeta Persad presented on climate change science and solutions. Her talk discussed her climate modeling research and how better models of the Earth's climate system can help inform better solutions for mitigating and adapting to climate change.

Professor Julia Clarke's talk was about dinosaur sounds. She shared how her research on modern-day birds is helping researchers envision what dinosaurs might have sounded like—and how it differs from the booming roars often depicted in Hollywood movies.

"Hot Science—Cool Talks" is presented by The University of Texas at Austin's Environmental Science Institute.

Two New Podcasts for Geosciences

During the past year, two podcasts were launched by scientists at the Jackson School of Geosciences: the "Water Resources Podcast," hosted by Senior Research Scientist Bridget Scanlon, and the "Science, Y'all" podcast, hosted by graduate students Noah Benitez-Nelson and Nick Regier.

Scanlon started the "Water Resources Podcast" in February to spark discussion on water supply issues and solutions for sustainable water management around the globe. On each episode, she welcomes an expert guest for a chat about their water research.

On the "Science, Y'all" podcast, Benitez-Nelson and Regier interview members of the Jackson School's research community, including students and faculty members. Each episode is 20 to 30 minutes and offers a chance to learn more about people at the Jackson School, particularly in the Department of Earth and Planetary Sciences.

"You meet people and see them in the hallway, but unless you're working with them closely, that's all you see," Regier said. "This is a great means of just getting to know these faculty better and building deeper roots to the department."

New episodes of the "Water Resources Podcast" air every other Thursday and are available on Spotify, Apple Podcasts and YouTube. "Science, Y'all" episodes are available on Spotify.

LEFT, TOP: PROFESSOR JULIA CLARKE DURING HER TALK ON THE SCIENCE OF DINOSAUR SOUNDS.
LEFT, BOTTOM: ASSISTANT PROFESSOR GEETA PERSAD SPEAKING ABOUT CLIMATE MODELS AND THE ROLE THEY PLAY IN MITIGATING AND ADAPTING TO CLIMATE CHANGE.
PHOTOS: ENVIRONMENTAL SCIENCE INSTITUTE.

Student Social Media Team Finds Success on Instagram

This spring, the Jackson School of Geosciences student social media team, which was formerly known as the "TikTok team," made the move to Instagram after Texas Gov. Greg Abbott banned state devices from accessing TikTok.

Although they are on a new social media platform, the team's mission remains the same: create original social media posts that highlight student life at the Jackson School, and spread the word about geosciences.

Five Jackson School students were on the team this spring: master's student Aya Bangun and undergraduate students Arushi Biswas, Christina Alana Raymond, Savannah Garza and Eden Lagnado.

The team's posts appear on the Jackson School's existing Instagram account at @txgeosciences. They include highlight reels of field and lab work, trending memes with a geosciences spin, interviews with members of the Jackson School community, and tours of Jackson School collections.

Together, their posts have garnered thousands of views, and are among the top-shared posts on the Jackson School's Instagram account.

Garza, who joined the team in February, is a first-year student majoring in environmental science. She said she joined the team to help get the word out about the geosciences—a field that she was unaware of until college.

"I like being on the social media team because we're helping give an insider look at what the Jackson School is like," she said. "We can help put everything in perspective here for people who don't know what it is like, as well as making sure our student perspective is seen by other people."

OPPOSITE PAGE: A SCREENSHOT FROM STUDENT CHRISTINA ALANA RAYMOND'S HUMOROUS POST ABOUT GEOLOGY TERMINOLOGY.

ABOVE, RIGHT: A STILL FROM A VIDEO TOUR OF THE BUREAU OF ECONOMIC GEOLOGY'S CORE REPOSITORY CREATED BY TEAM MEMBER AYA BANGUN.

PHOTOS: JACKSON SCHOOL .

Space Outreach Program Joins UTIG

The Texas Space Grant Consortium helps encourage careers in space research and exploration by offering grants and hosting student science and engineering competitions. In late fall 2022, they became a part of the University of Texas Institute for Geophysics (UTIG).

Texas Space Grant is the Texas branch of the National Space Grant College and Fellowship Program, an outreach initiative established in 1988 to advance U.S. space science. It was previously associated with The University of Texas at Austin Center for Space Research. UTIG Director Demian Saffer said that the institute was a natural fit for Texas Space Grant.

"We have folks here who are designing the instruments that are going to Europa, who are modeling geo-dynamos on gas giants, and who are investigating whether life could exist on other planets," he said. "There's a lot to be leveraged here."

Texas Space Grant provides funding for undergraduate scholarships, graduate fellowships and stipends for internships at NASA and other space exploration organizations. It also coordinates engineering contests, such as NASA's Micro-g NExT challenge. Student-designed tools from this challenge have made their way to the International Space Station, including zip-tie cutters designed by a team from Lone Star College in Houston in 2017. The cutters fit snuggly into astronaut gloves so they don't float away during space walks.

With Texas Space Grant now settled into its new home at UTIG, its priority is to partner with more schools, find new funding sources and increase higher education STEM opportunities, said Tim Urban, the director of the program.

"I would like to have more industry involvement especially with so many Texas companies getting into the space race," he said.

Texas Space Grant can be found at ***www.tsgc.utexas.edu***.

ABOVE: UT TYLER STUDENTS PRESENT AN UPGRADE FOR NASA ROBOTIC ARM TESTING AT TEXAS SPACE GRANT'S SPRING 2023 DESIGN CHALLENGE.
PHOTO: TIM URBAN/TSGC.

Dazzling Gem and Mineral Gallery Opens in UT Geology Library

A new gem and mineral gallery at the Jackson School of Geosciences offers an eye-catching array of geological specimens meant to delight and inspire visitors. The specimens range from sparkling gemstones, to unusual crystals, to a wall of minerals that turn bright highlighter hues under ultraviolet light.

The Henry R. and Ann H. Hamman Gem and Mineral Gallery is in the Walter Geology Library on the fourth floor of the Jackson Geological Sciences Building on The University of Texas at Austin campus, and it is open to the public from 1-4 p.m. on weekdays.

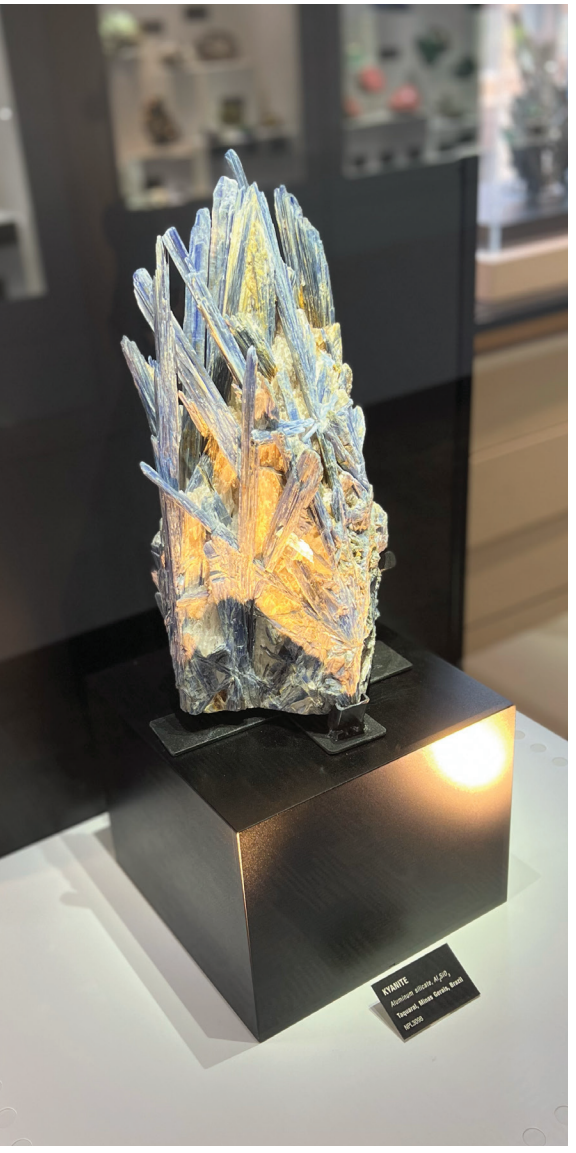
The gallery is named in honor of longtime Jackson School supporters Ann and Henry Hamman, who funded the gallery's construction and paid for many of its specimens. Henry Hamman earned Bachelor of Science and Master of Arts degrees in geology from UT. He passed away on May 11 shortly after the gallery's opening in February.

The idea for a gallery in the library started with Dennis Trombatore, who served as the geology librarian for over three decades. With most journals and magazines available online, Trombatore envisioned repurposing the periodical reading room into a mineral gallery where people could learn about—and admire—the geological specimens in the school's collections. Trombatore passed away in 2020.

Mark Helper, a senior lecturer emeritus who was involved with establishing the gallery from beginning to end, said that it fulfills Trombatore's vision.

"He wanted to draw people to the library, and he knew the gallery would do that," Helper said. "I think he would have been thrilled to see it."

The gallery features minerals that are both new and old to the school. They include an array of the very best specimens of the school's E.M. Barron Mineral Collection and hundreds of faceted gemstones from the Glenn and Martha Vargas Gem and Mineral Collection. These are complemented by about 100 new dazzling mineral specimens, selected and purchased with the aid of the Houston Museum



Remembering Henry Hamman

Henry R. Hamman was an alumnus and long-time supporter of the Jackson School of Geosciences. In addition to the Henry R. and Ann H. Hamman Gem and Mineral Gallery, Hamman's generosity supported scholarships and programs at the Jackson School. More on Hamman on page 106.

LEFT: A KYANITE SPECIMEN FROM SÃO PAULO, BRAZIL.
ABOVE: MINERALS GLOW UNDER ULTRAVIOLET LIGHT.

OPPOSITE PAGE: GALLERY SPECIMENS WITH THE UT TOWER IN THE DISTANCE.

PHOTOS: JACKSON SCHOOL.

of Natural Science. Among these are large gem aquamarine specimens from Afghanistan and a purple cluster of spherical "grape" amethyst crystals.

The Houston museum is famous for its own gem and mineral collections and outstanding displays. Hamman arranged for Houston museum staff members to be involved in the school's gallery from the beginning, assisting with the design phase, the building and purchase of custom cases and cabinetry, and the selection of state-of-the-art lighting. The collection opts for star power over presenting a comprehensive guide to minerals, Helper said. Artist and exhibit designer John Maisano took the lead on selecting the most attractive specimens to fill the space, and arranging and lighting them. His favorite piece in the collection is a 1,778-carat blue topaz gemstone, lit from below so the light shines thought it.

"It looks kind of like a star," said Maisano, who retired this spring (see sidebar). "It's in the back, so it draws you through the room, and it's just spectacular."

The opening of the new gallery comes just as the Jackson School is revamping its own gem and mineral education. The school recently hired Kenny Befus, a Jackson School alumnus and former associate professor at Baylor University, to teach the gem and mineral course and oversee the collections. Befus established a similar course at Baylor and will be continuing his research on gems as an associate professor of professional practice at the Jackson School.

Maisano Brings Artist's Eye to Jackson School Science

The Henry R. and Ann H. Hamman Gem and Mineral Gallery was the final exhibit created by John Maisano, the resident artist at the Jackson School of Geosciences, before he retired in spring 2023.

"It was a nice way to go out," said Maisano. "It was great to work with Mark (Helper) on such a huge project."

Maisano's exhibits can be found in the halls of every floor of the six-story Jackson Geological Sciences Building, save for the basement. They present a wide array of science and in many cases connect it back to Jackson School researchers involved with the work.

"It really is a way to bring out what's going on in the back rooms, and to bring all that research that's being done out into the public," he said.

Maisano got his start in exhibits at the Yale Peabody Museum in 1989. In 2000, he moved to Austin and began working at the Texas Memorial Museum (recently renamed the Texas Science & Natural History Museum), where he designed and built the paleontology exhibit—the museum's signature attraction—among many others. He joined the Jackson School in 2015.

Maisano is also a talented sculptor. His creations include the bronze saber-toothed cat at the entrance of the Texas Science & Natural History Museum and an *Ornithomimus* dinosaur in the Hartman Prehistoric Garden within the Zilker Botanical Garden.

Jackson School Enters a New Era of Field Camp

Change is coming to GEO 660, the foundational summer geology field camp of the Jackson School of Geosciences.

Starting next year, the camp will run on a three-week schedule instead of the six weeks of years past. Leading GEO 660 will be a new field camp director, Miriam Barquero-Molina.

The three-week schedule will enable students to spread out their field camp experience into two trips, said Danny Stockli, the chair of the Jackson School's Department of Earth and Planetary Sciences, with field visits being split up across two field camp sections—GEO 660A, aimed at sophomores, and GEO 660B, for students at the end of their junior year.

In addition to helping students build and improve on their field skills during their college careers, Stockli said that it should get students into the field sooner. Because of the six-week field camp's time commitment, many students delayed taking field camp until their final year in college or even the summer after graduation. This situation often led to a big gap in time between students taking field methods, which is frequently taken early in college, and getting to apply those skills.

"We want a field camp experience that is less trial by fire," Stockli said. "We want students to have the opportunity to grow and develop from one trip to the next."

The field camp will still take students to visit sites in West Texas, New Mexico, Utah and other locations across the country.

The camp will occur in May, the same time as the Jackson School's two other field camps, hydrogeology and marine geology and geophysics. The new timing has the added benefit of occurring during the UT "Maymester" schedule, which enables summer field camp tuition to be covered by spring tuition at no additional cost to students. Funding from Jackson School endowments previously covered field camp tuition for all students. Now, this funding can be applied elsewhere to other aspects of the field camp experience, such as field technology.

The timing also offers students more flexibility, Stockli said. A three-week course in May leaves most of the summer free so students can attend to other things, whether that's internships or summer jobs, or personal or family obligations.

"I think this flexibility is a major benefit, a quantum leap forward in terms of inclusivity," Stockli said. "Students are done at the end of May, so they can go do that internship, or take that summer job that they need, or take care of their children if they have them."

Charlie Kerans, a professor in the department, led this year's GEO 660 field camp as interim director, filling the space left by the camp's former director, Mark Helper, who retired from the Jackson School last fall.

Next year, Barquero-Molina will take the reins as the new director of field camp. Barquero-Molina earned a doctorate from the Jackson School in 2009 and helped lead the school's field camp during graduate school.

"It's a coming home of sorts for me," she said. "The Jackson School has always felt like home because during a critical stage of my life it was my scientific home, and I feel pride and joy to be a part of it again."

Previously, Barquero-Molina was field camp director and associate teaching professor at the University of Missouri, where she led Camp Branson, the university's six-week field camp in Lander, Wyoming, for 13 years.

In 2014, Barquero-Molina was recognized by the Geological Society of America with the GSA/Exxon Mobil Field Camp Excellence award.

ABOVE: JACKSON SCHOOL VOLCANOLOGY PROFESSOR JIM GARDNER TEACHING FIELD CAMP STUDENTS ABOUT MAGMA-WATER INTERACTIONS AND EXPLOSIVE VOLCANIC ACTIVITY IN THE FRIJOLES CANYON, BANDELIER NATIONAL MONUMENT, NEW MEXICO.
PHOTO: WADE AUBIN.

LEFT: SUSIE COOK (IN GREEN) AND OTHER UNDERGRADUATE STUDENTS WORK ON A SEISMIC INTERPRETATION OF THE WIND RIVER BASIN IN WYOMING.
MIDDLE, LEFT: JUAN VASQUEZ, LILY ALAMEDA, GRACE BARTUNEK, RAMA YOUNES AND YASHODA JOSHI EXAMINE THE BANDELIER TUFF NEAR LOS ALAMOS, NEW MEXICO.
MIDDLE RIGHT: MITCHELL CASAZZA (LEFT) AND ELLA CLARK ADMIRE FREMONT CANYON AT THE GREAT UNCONFORMITY IN CASPER, WYOMING.
BOTTOM LEFT: THE GROUP DISCUSSING THE BEST ROUTE UP TO THE ROCKS ABOVE GHOST RANCH NEAR ABIQUIU, NEW MEXICO.
BOTTOM RIGHT: GEO 660 STUDENTS STUDYING ACTIVE DUNE PROCESSES AT WHITE SANDS NATIONAL PARK, NEW MEXICO.

PHOTOS: WADE AUBIN.

GEO 660

GEO 660 saw changes this year. Some students took the usual six-week field camp, while others joined an earlier three-week schedule that's set to become the standard next year. The camp visited sites in New Mexico, Utah, Wyoming and Montana, and was led by interim director Charlie Kerans and lecturer Peter Hennings.

hydro

The hydrogeology field camp explored the alluvial and karst hydrogeologic settings of Austin, Texas, and Tulum, Mexico. In Tulum, the students mapped the water table of a barrier island in the Sian Ka'an Biosphere Reserve and gathered water samples from nearby cenotes (sinkholes), guided by volunteer divers.

TOP LEFT: UNDERGRADUATE STUDENTS NADER AL-RIFAIE AND AMBER NGUYEN COLLECTING WATER SAMPLES FROM A CENOTE IN TULUM, MEXICO;
TOP RIGHT: ANALYZING WATER QUALITY AT HORNSBY BEND, AUSTIN. THE AUSTIN AREA PART OF THE FIELD CAMP WAS SUPPORTED BY EDWARDS AQUIFER AUTHORITY, HAYS TRINITY GCD, AND AUSTIN WATER. (L-R) JOJO SANANDA, SUMMER MONTOYA, AUSTIN LUU, JASON DAHLBERG, MADISON CALLAN AND SNEHA NACHIMUTHU;
ABOVE: (L-R) INSTRUCTOR AND ASSOCIATE PROFESSOR DANIELLA REMPE WITH STUDENTS MADISON CALLAN, AUSTIN LUU AND SUMMER MONTOYA AT THE SIAN KA'AN BIOSPHERE RESERVE IN MEXICO. THIS PHOTO WAS SHOT BY A DRONE THEY USED TO SURVEY THE AREA.

PHOTOS: JACKSON SCHOOL.

LEFT: STUDENTS ANALYZING SAMPLES TAKEN TO STUDY THE WATER TABLE OF A BARRIER ISLAND AT THE SIAN KA'AN BIOSPHERE RESERVE, MEXICO. (L-R) XANDER KELLY, ELIZABETH COLLINS AND BERIT HUDSON RASMUSSEN.
PHOTO: JACKSON SCHOOL.

MG&G

The Marine Geology & Geophysics class travelled to Port Aransas to study the coastal geology of Corpus Christi Bay. Students took to the sea, air and shore to look for damage caused by sand dredging and storms and learned many new things about the region's geologic history.

TOP: (L-R) INSTRUCTOR MARCY DAVIS PILOTS THE R/V SCOTT PETTY AS STUDENTS SORAYA ALFRED, MACLEAN LANDAU AND MANDALA PHAM MONITOR THE VESSEL'S SEAFLOOR-SCANNING SEISMIC IMAGING INSTRUMENTS.
ABOVE, LEFT: THE VIBRACORE TEAM APPLY SOME ELBOW GREASE TO RETRIEVE A SEDIMENT SAMPLE FROM THE SHALLOWS OF CORPUS CHRISTI BAY. (L-R) JACOB MARGOSHES, CARSON MILLER AND KEVIN SHIONALYN.
ABOVE, RIGHT: GUEST INSTRUCTOR MARIEL NELSON DEMONSTRATES THE LIDAR-EQUIPPED DRONE, KNOWN AS GRACKLE.

PHOTOS: JACKSON SCHOOL.

RIGHT: THE ONSHORE TEAM EXAMINES SEAFLOOR SEDIMENT SAMPLES FOR MICROSCOPIC EVIDENCE OF DREDGING IMPACTS. (L-R) GRAD STUDENT PATTY STANDRING, INSTRUCTORS LORNA KEARNS, ADAM WOODHOUSE AND CARSON MILLER.
PHOTO: JACKSON SCHOOL.

Q&A With Danny Stockli on Department's New Name

After more than 50 years as the Department of Geological Sciences, the geosciences department at The University of Texas at Austin has a new name: The Department of Earth and Planetary Sciences.

But what's in a name?

Anton Caputo, the editor of The Newsletter, sat down with Danny Stockli, the chair of the newly named department, to learn more about the reason for the name change and what it says about the department now and going forward.

Caputo: Thanks for chatting with me, and congratulations on the new department name. Why did you think it was time for a change?

Stockli: Over the past decade or more, the thematic footprint of the Jackson School of Geosciences and the department has dramatically changed. We are still doing cutting-edge geology, but people are doing a lot of other things too. We have expanded much more into climate and planetary research, and other cross-disciplinary work. To be frank, the old name didn't represent us well.

We're not alone in this situation either. Many other geosciences schools and departments across the country have changed their names in recent years to better reflect the scope of study that geosciences encompass. There are very few holdout "departments of geology."

I think the new name, the Department of Earth and Planetary Sciences, really captures a more inclusive, more representative vision. It communicates who we've become, what we do, what we teach, and to some extent, who we want to be.

Caputo: How did the school decide on the new name? What was the process like?

Stockli: You know, it's been talked about in sort of a rumor mill way for years. But when I became chair in 2020, about three-quarters of the faculty signed a letter to me saying that they would like me to consider a name change for the department. That was the formal starting gun, so to speak.

I put together a committee that actually was spearheaded by a geologist, Charlie Kerans. I also engaged the graduate students, undergraduates, the alumni, the development office, and the dean, of course.

We found that folks really felt that "Earth and planetary" was our most inclusive realm, without picking winners and losers, while also being representative of not just current faculty and students, but of alumni and future members of the school.

Caputo: What has been the reaction to the new name?

Stockli: I've presented it to the undergrads, the grad students and the alumni, and we've had uniformly positive responses. Geology is just one building block, but Earth sciences is a vision of an entire system—the planet, with the lithosphere, hydrosphere, the biosphere and the atmosphere. I think this vision is much more us.

Caputo: So, will geological sciences and geology be taking a back seat to other disciplines?

Stockli: Au contraire! We are still very strong in geology. We still train a lot of students in geology and do a lot of geological research. But it's just one subject in a much larger sort of geoscientific repertoire. And it's important for students to realize that.

Caputo: Can you talk more about that? What do you want prospective students to know?

Stockli: The geosciences are at the heart of global issues, whether that's climate change, whether that's the energy transition, whether it's sea level change, whether it's natural resources—you name it. It's clear that the job market is evolving in response to all of these issues, and we need a lot more geoscientists to address them all.

We're hoping the name change will help us attract students that we can train to tackle all these problems, and who at the same time are willing to reinvent themselves. The problems are changing so rapidly that we have to be willing to change too. We can't be stagnant—that goes for curriculum, that goes for research, that goes for who we are as geoscientists.

Caputo: That's a good segue for my next question. The name change has come at the same time as some big changes to the undergrad curriculum. Can you describe them?

Stockli: So, there are three main thrusts. The first is that we have opened up the aperture at the beginning so that students have more opportunity to be exposed to the geosciences. Previously, all undergraduate students majoring in

geosciences had to start by taking intro to geology. But now, we are allowing all introductory classes we teach to count as the entry class, so students can start with, for example, intro to climate or oceanography or natural hazards.

Second, we have created a core curriculum for all geosciences majors in the department. That means for the first two years all geosciences students will get the same exposure to experiential courses and data courses. These students are going to get exposed to the breadth and depth of all the geosciences. We're doing that to make sure our students are fully formed, fully educated scientific experts that can have the knowledge and the skills to explain today's issues.

Third, is that we are introducing a new undergraduate major in climate system sciences. It's a technical major, so students will learn how climate models work, how risk is calculated, and how different climatic systems influence one another. The major will officially launch next year, but students can start taking classes toward the degree now.

Caputo: The department is one of the oldest on campus, dating back to 1888. How has it changed over the years? Where do you see it going in the future?

Stockli: For most of the department's history, I think it's safe to say that most students who entered the school had their sights on a career in oil and gas. It was one of the most reliable pathways for geoscientists to have successful, fulfilling careers and to provide a real societal need—energy. The connection between geology and the oil and gas industry—especially here in Texas—also informed faculty research interests, and funding, too.

The reality today is that there are more pathways than ever for geoscientists. A career in oil and gas has gone from being a primary pathway to one among many. The energy transition and climate change are bringing big changes to how industry operates as well, along with creating brand new opportunities for geoscientists.

In terms of research expertise, the department of today is already quite different from the department of 10 to 15 years ago, hence the new name. Undergraduate and graduate students come to the school with a wider array of interests. They want to find solutions for climate change, for water issues. We're dealing with a much more diverse set of problems these days that we geoscientists have the skills to address. I don't see that stopping anytime soon.

New Department Name, New Undergrad Curriculum

The undergraduate geosciences curriculum was recently updated to better reflect the skills and expertise needed by geoscientists today. Here are three key takeaways.

1. Students don't have to start with geology.
Previously, undergraduates began a degree in geosciences by taking "Introduction to Geology." Now, students can start with any introductory course—such as climate, oceanography or natural hazards—allowing many potential entry points into the geosciences.

2. All geosciences majors share a core curriculum.
Starting next year, all geosciences students will share a core curriculum during the first two years of college. This will ensure that geosciences students specializing in different fields are exposed to a breadth of experiences and skills, including field and data science skills.

3. A new major in climate system sciences is coming.
This degree option will officially launch in 2024, but undergraduate students can start taking courses toward it now. The degree is technical and covers contemporary climate variability and climate change, how climate models work, and how risk is calculated.

OPPOSITE PAGE: DEPARTMENT CHAIR DANNY STOCKLI.
PHOTO: JACKSON SCHOOL.

ABOVE: RESEARCHERS ON A UT-LED MISSION TO STUDY GREENLAND'S ICE SHEET.
PHOTO: JASON GULLEY.

Starting in the Field: An Update on GEO 401, "Physical Geology"

Introductory courses in geosciences have always been an important pathway for inspiring and developing enthusiasm among new students, and for framing a perspective on the many pathways students can take as they launch careers in modern geological sciences.

During the COVID-19 shutdown, we looked forward to a return to normalcy in classroom instruction but also allowed ourselves to explore the idea of a new model for teaching introductory geology—teaching "intro" as a field-based course.

The Department Executive Committee approved our proposed plan, and we worked together to develop an assessment plan for the new course. The pilot offering happened in the Fall 2021 semester, and we are now in our third year of teaching and assessing a field-based version of GEO 401, "Physical Geology."

First-year students select this section of GEO 401 during their orientation, and enrollment is currently limited to 18 students. The course is centered on experiential, field-based instruction, with students in the field every Friday for four hours, and in the classroom for one hour each Wednesday, so we can introduce new topics and concepts before heading outside.

Students also participate in a one-hour "debrief" each week where they can contextualize their field observations and experiences, and we can address lingering questions and provide clarifications.

The course provides excellent opportunities for students to form a lasting cohort with their peers and also to get to know their professors under less formal circumstances than is often afforded to them in traditional classroom and laboratory settings. And they are starting their exploration of geosciences with experiential learning in the field!

—Professor Christopher J. Bell, Lecturer Mary F. Poteet, Professor David Mohrig, and Lecturer Adam Papendieck

CLOCKWISE FROM TOP: DAVID MOHRIG LEADS A DISCUSSION AT MCKINNEY FALLS STATE PARK; KYLE SPIKES LEADS A SEISMIC INTERPRETATION ACTIVITY; STUDENTS IN THE FIELD AT ROY GUERRERO COLORADO METRO PARK.
PHOTOS: CHRISTOPHER BELL.

Academic Programs Supporting Future Geoscientists

Each student has a unique journey to the geosciences. The Jackson School of Geosciences runs a variety of programs that help support geosciences students —and prospective and potential students—throughout their academic careers, from the start of high school on to graduate school.

This year was a particularly successful one, with programs reaching a record number of students and increasing the involvement of scientists from across the Jackson School's research units.

The Jackson School's award-winning GeoFORCE program saw its highest number of participants yet, with a total of 512 students from Houston, Austin and Southwest Texas schools taking part this summer. The program helps Texas high school students from underserved areas learn about the geosciences and the college application process during summer field trips to sites across the country.

About 42% of GeoFORCE students go on to study a STEM field in college. The Jackson School's Math and Science Institute gives GeoFORCE graduates a chance to prepare for the rigorous math and science courses ahead, as well as to learn from peer learning assistants about college life. This summer, the weeklong institute took place on The University of Texas at Austin campus and included 32 GeoFORCE graduates—about 36% of the 12th grade cohort and the highest number of students to enroll in the institute. Seven of the students are majoring in geosciences, with five enrolled at the Jackson School. Thirteen of the students are enrolled at UT.

The Jackson School also hosted 20 students this summer for its Research Traineeship Experience (RTX) program, double the number that participated in 2022. The program is open to recent STEM graduates and STEM undergraduates, including students enrolled in community colleges, with plans to enroll in four-year universities. This year students came from as far away as Alaska and Puerto Rico.

The nine-week program brings students to the UT campus where they are paired with mentors from the Jackson School community, including faculty, research scientists, postdoctoral scholars and graduate students, and participate in learning modules that teach technical skills used in geosciences and STEM research. This year's mentors included researchers from all three of the Jackson School's research units. Following the program, two RTX students also attended a graduate-level workshop hosted by Professor Thorsten Becker on megathrust earthquake modeling. All 20 of the students gave poster presentations on their research at a UT-wide summer symposium. What's more, some of the RTX students will be sharing their research findings during student poster sessions at the annual meetings of the American Geophysical Union and the Geological Society of America.

The Jackson School's Gateway to Graduate Studies in Science program (G2S2) also had over 90 applicants, triple the previous record. The program, which was formerly called EDGE, invites a group of prospective graduate students to visit the Jackson School —with all travel, food and lodging costs covered—so they can meet current students and faculty members and learn about research and funding opportunities at the school.

Jackson School Dean Claudia Mora said that the programs create a geosciences "ecosystem" of sorts, building a diverse web of community connections and tangible support. She said that she was thrilled to see so many people, from high school freshmen to seasoned scientists, taking part.

"These programs can help the next generation of geoscientists succeed not just today, but in the long run, too," Mora said.

If you're interested in supporting these programs, please contact Chief Development Officer Andrew West, ***awest@austin.utexas.edu***

ABOVE: A GROUP SHOT FROM THE RTX RESEARH SYMPOSIUM IN THE JACKSON SCHOOL'S HOLLAND FAMILY STUDENT CENTER.
PHOTO: DANA THOMAS.

A Day in the Life of a Field Geologist in Japan

Morning

Matsuyama, Shikoku Island, Japan — I put on my robe and wooden slippers and clunk down to the *onsen*, a natural hot spring. After catching the sunrise through the bamboo, I put on my field gear for the day. Breakfast is miso soup, rice, seaweed salad, and tofu with some coffee. I pile in the car with Hironubu Harada and Tsujimori Tatsuki of Tohoku University in Sendai, and Maureen Fineman, Ella Do, and Yusuke Hayashi of Penn State University. We meet the rest of the crew and grab the usual kelp onigiri and Jasmine tea that no field day is complete without. After that we're off.

Afternoon

Waves lap at our feet as we scramble along slick rock, hammers at our fingertips ready to sample.

Japan's geology is complicated and unique. It hosts an active subduction zone that runs into an exposed paleo-subduction zone along the ancient plate interface, meaning rocks from deep underground are now exposed at the surface. We are sampling a continuous suite of rock for geochemical analysis ranging from around three kilometers to subarc paleo-depths at paleo-temperatures of 220° Celcius to around 500°Celcius in the Shimanto and Sanbagawa Belts on Shikoku Island in Japan.

We are looking at the evolution of boron's geochemical behavior in subduction zones. Boron is important to us for two reasons. One, boron is highly fluid-mobile and partitions between rock and fluid based on temperature. Two, boron is a volatile element that is essential to plant life. It's also a part of the chemical compositions of our oceans, magmas, and the mantle.

We can use the samples we're gathering to trace fluid flow in subduction zones by looking at the changing boron concentration with depth. Fluids are an integral piece of the puzzle in determining the magnitude and timing of earthquakes. We can also look at how boron concentration changes during progressive subduction to determine the distribution of boron within oceans, magmas and mantle as it cycles through the Earth.

We scramble along an outcrop of ancient mélange, giant sections of ribbon chert, sandstone, and mudstone beneath our feet. We cannot go as far as we would have liked to as the ocean has covered a part of our path. We turn back and head into town.

Yusuke leads us around tight turns on a small one-way road in the mountains of Shikoku, the Asemi River on our left and a mountain to our right. The river runs through a post-depositional fold increasing in metamorphic grade from chlorite to its peak oligoclase-biotite zone from south to north. This is a beautiful transect of the paleo-subarc, and we get to work sampling metamorphosed pillow basalt, garnet rich rocks, and metamorphosed chert. After a long day, we head to dinner.

Evening

We walk through the curtains of an *izakaya*, a Japanese pub, exhausted. Peeling off our field boots, we slide onto our mats, secluded from the rest of the world by rice paper doors. I look around at everyone from all these different walks of life and remind myself how lucky I am. My job is to learn about subduction zones, hike over mountains and coasts, and work with people from all over the world.

Nicole Ferrie,
Doctoral Student

ABOVE, LEFT: GRADUATE STUDENT NICOLE FERRIE WITH AN EXCAVATED ECLOGITE ON DISPLAY AT THE NIKUBUCHITANI RIVER IN EHIME, JAPAN.
ABOVE, CENTER: FERRIE GATHERING SAMPLES OF PILLOW BASALT FOUND ALONG THE ASEMI RIVER IN KOCHI, JAPAN.
ABOVE, RIGHT: FERRIE CHIPS AWAY AT SHALE THAT WAS ONCE THE ACCRETIONARY WEDGE OF AN ANCIENT SUBDUCTION ZONE.

PHOTOS: ELLA DO.

Downloading Earthquake Data from the Bottom of the Ocean

In March 2023, I traveled to Wellington, New Zealand with a group of UT scientists to study subduction zone processes at the Hikurangi subduction zone. The Hikurangi subduction zone is of particular interest to scientists due to the occurrence of slow slip events which occur every 1-2 years and have the potential to release accumulated strain that may otherwise be released in large earthquakes. Understanding slow slip events is crucial for developing seismic hazard models for New Zealand which help protect and prepare the public in the event of a large earthquake.

In order to better understand how these slow slip events occur, two CORK observatories were installed into the sea floor during a 2018 International Ocean Discovery Program (IODP) expedition. These observatories allow scientists to measure pressure and temperature as well as collect geochemistry samples from sites that are 100s of meters below the seafloor and are very challenging to access. Five years after the initial installation of these CORK observatories, I boarded the *R/V Thomas Thompson* with scientists from around the world and WHOI's remotely operated vehicle (ROV) Jason and crew. Our primary objective was to collect pressure, temperature, and geochemistry data stored within the CORKs and re-deploy new sensors into the observatories.

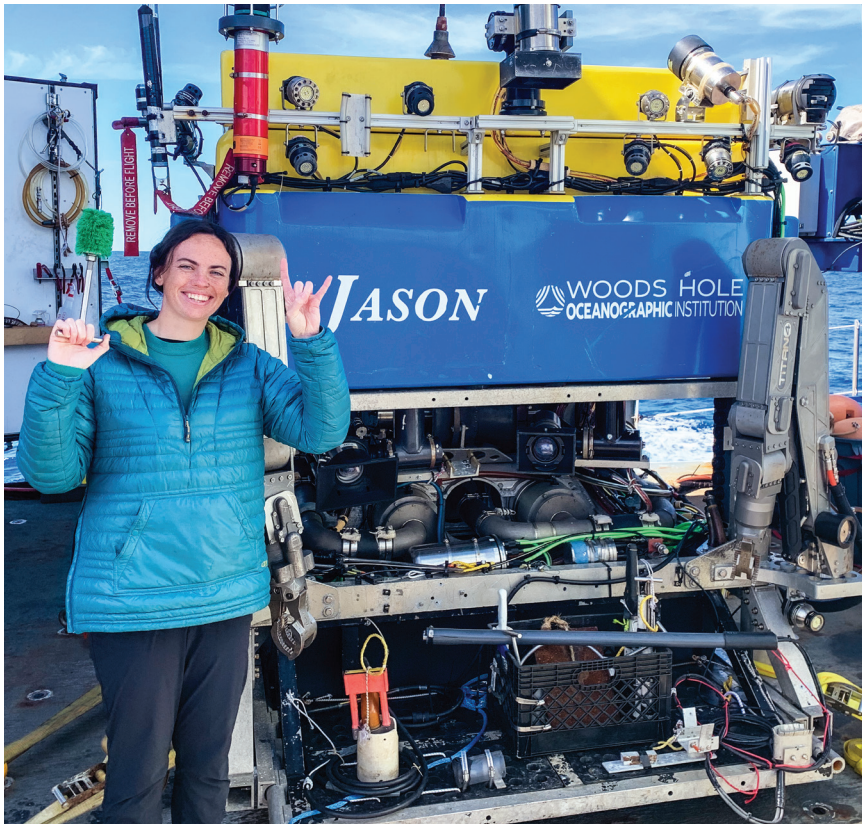
It is extremely difficult to retrieve data and deploy new instruments at sites that are located multiple kilometers underwater. Thankfully, WHOI's Jason crew are experts at accessing remote underwater sites with the ROV. As part of the scientific team, I worked with the Jason crew to retrieve the data and sensors from the CORK observatories. We then prepared new pressure and temperature sensors to be deployed. The temperature and pressure sensors are strung onto a long cable (over 100 meters) and lowered from the deck of the *R/V Thompson* all the way to the observatory on the seafloor. For a scale reference, this operation is like lowering a spaghetti noodle through the deep end of a pool and guiding it into a straw.

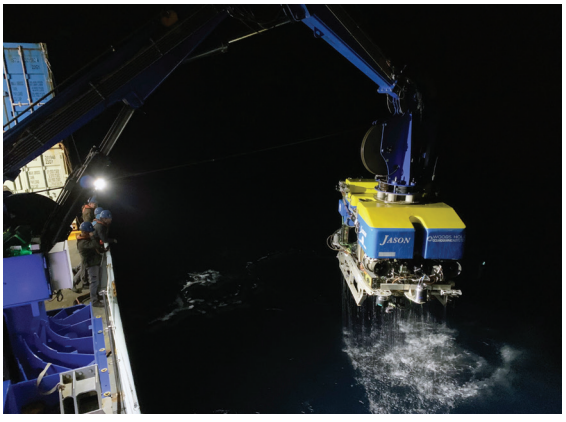
Overall, we successfully recovered pressure and temperature data that will be used to further study slow slip events and subduction zone processes. Participating on the research cruise was a great opportunity for me to collaborate with other scientists that are excited about studying earthquake processes, and it was amazing to see the scale and intricacies behind scientific ocean drilling and instrumentation. It is truly incredible that we are able to collect high resolution data from extremely remote sites, and this research will allow scientists to develop improved assessments of seismic hazard for the people of New Zealand.

Kaitlin Schaible,
Graduate Research Assistant

BELOWE, CLOCKWISE FROM LEFT: KAITLIN SCHAIBLE FLASHES A HOOK 'EM NEXT TO WHOI'S REMOTELY OPERATED VEHICLE; THE ROV IS RETRIEVED AFTER ITS MISSION TO THE OCEAN FLOOR BOREHOLE OBSERVATORY; THE SCIENCE TEAM WATCHES THE ROV'S PROGRESS FROM THE CONTROL ROOM.

PHOTOS: KAITLIN SCHAIBLE





Transport on the Trinity: Erosion & Bank Failures

Liesel Papenhausen is an undergraduate research assistant working with Jackson School doctoral student Mariel Nelson. In 2023, Papenhausen joined Nelson and her supervisor Assistant Prof. Tim Goudge on field research to study changes in Texas's Trinity River.

Texas is one large relief gradient. Beginning in the mountains in the west, water travels from these high-velocity headwaters, sloping downward to become meandering channels in the east. The Trinity River is the longest watershed held wholly within the borders of Texas, snaking its way past the city of Houston. Here, we study the small-scale erosion events of the cut bank, where higher velocity waters carve away to sculpt new bends and oxbow lakes.

We use a range of data collection methods to inform exactly when a bank will fail, and what encouraged the sediment to crash into the water. Two drones are used, one with an attached LIDAR system and the other with a camera to take photos from a bird's-eye view. The LIDAR system sends light pulses down to the vegetation, bank, and water, collecting data points that are used to digitally reconstruct the river bank. Comparing these over time, we see how the river is changing over short time scales. Additionally, we have a system of trail cameras taking a photo every hour. The time-lapse photos reveal a unique view of the eroding cut bank that can be qualitatively analyzed. The most unique event in these time-lapses was a series of three bank failures, all within the same hour. These happened because there had been neither rain nor flood for over a week, leaving the soil dry and brittle until it could no longer support itself. From gradual creeping to mini-landslide events, the river is constantly evolving; this is the nature of meandering rivers. Winding upon itself until it reaches the ocean.

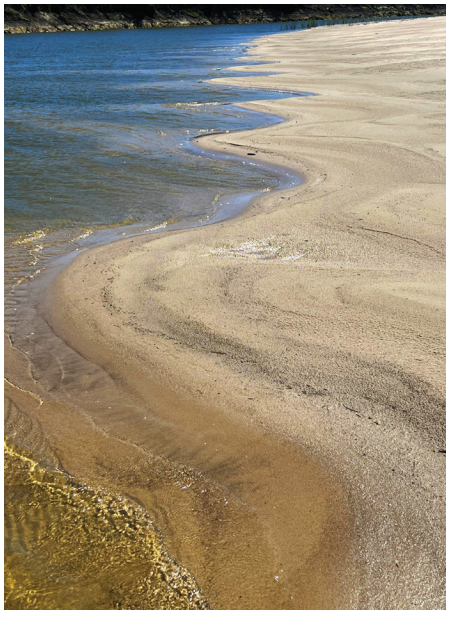
The research also aims to understand the speed at which weathering facilitates the transport of sediment. In the event of a chemical spill, studying small-scale erosion events can help predict the speed at which contamination will spread. This will help experts make decisions on when evacuation is necessary, and who is at the greatest risk.

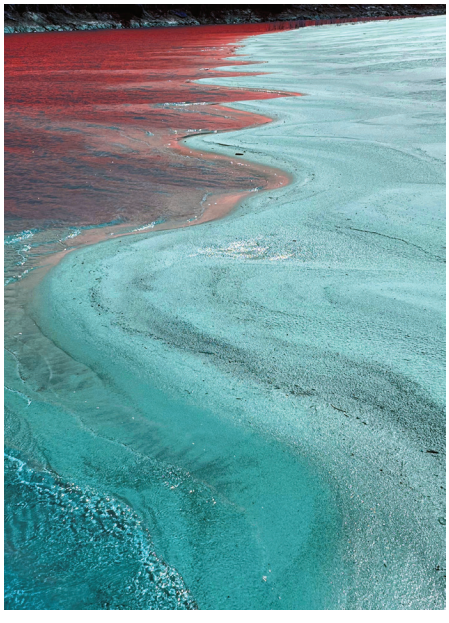
I encourage all undergraduate students to pursue undergraduate research assistant positions. I have learned better organization and presentation skills, been given advice for research conferences and graduate school, and enriched the information I have learned through my classes at UT. From informing my career goals to helping me feel comfortable in research settings, this experience has been truly invaluable. I am so thankful to Mariel, Dr. Goudge and the Planetary Research Group.

Liesel Papenhausen,
Undergraduate Research Assistant

ABOVE, LEFT: A DRONE EQUIPPED WITH A LIDAR INSTRUMENT FOR MAPPING THE BANKS OF THE TRINITY RIVER.
ABOVE, RIGHT: A SMALL DRONE NICKNAMED "THE ROBIN" TAKES PICTURES OF WATER AND RIVERBANKS.
BELOW: TWO VIEWS OF THE TRINITY RIVER. THE COLORS HAVE BEEN PROCESSED IN DIFFERENT WAYS.

PHOTOS: LIESEL PAPENHAUSEN





New-Look Field Class Explores Sedimentology and Stratigraphy in California

Last October we took a 5-day tour of deep-water sedimentology and stratigraphy in northern and central California. The trip made up the field seminar component of GEO 383: Clastic Depositional Systems, now taught by me, Matt Malkowski, one of the Jackson School's new assistant professors, and GEO 383U: Dynamic Field Stratigraphy, taught by Prof. Brian Horton.

Horton and I led a group of 10 students along a suite of textbook outcrops that take students on a complete transect through a deep-water depositional system, from the head of a submarine canyon to the deposits of the deep abyssal plain. Along the way, we focused on observing, describing, and synthesizing facies to infer depositional process. The systematic transect allowed students to compare and contrast observations at each location and make predictions about what they will see at the next, "downslope" location.

We also discussed the progression of outcrops in the context of larger-scale tectonic, climatic and eustatic drivers contributing to stratigraphic changes along the way.

We visited some spectacular exposures along the scenic California coast and in the Coast Ranges further inland. Some highlights included the Pigeon Point Formation along the San Mateo coast, canyon fill strata at Pt. Lobos, a transect of the Cretaceous Great Valley Group, and the grand finale at the Marin Headlands. While most of the trip emphasized Cretaceous to Eocene stratigraphy, we also stopped at the Monterey Bay Aquarium Research Institute to get a behind-the-scenes tour of the tools and techniques that geologist Charlie Paull and his team use to study modern sedimentary processes in the Monterey Submarine Canyon.

We were pleased to hear that students found the field experience greatly helped their learning. This is a selection of their feedback:

"I thought the field trip was the most effective teaching tool. Seeing the rocks and placing myself in the depositional environments allowed me to make those in-class connections. The field notebook and field report were also very effective teaching strategies."

"The aspect of the course that was the most effective was the course field trip. While pictures and lectures are a great way of teaching the material, it cannot be compared to seeing what we talk about in class in person. Going on the field trip put things in a better perspective regarding the class content."

Matt Malkowski
Assistant Professor, Department of Earth and Planetary Sciences

CLOCKWISE FROM LEFT: MALKOWSKI (RIGHT) LEADS A DISCUSSION AT THE SITE OF AN ANCIENT SUBMARINE CANYON; THE CLASS DISCUSSES SUBDUCTION AMONG THE CALIFORNIA COAST RANGES; LOW-DENSITY TURBIDITY CURRENT DEPOSITS ALONG THE COAST IN SAN MATEO COUNTY, CALIFORNIA; GRAD STUDENT JANA ALABDULLATIF EXAMINES A CRETACEOUS-ERA DEEP-WATER FORMATION.

PHOTOS: BRIAN HORTON/JACKSON SCHOOL.

Stephen Grand

Professor Emeritus

By Monica Kortsha

STEPHEN GRAND

After a stellar career in seismography, Professor Stephen Grand retired this fall. His scientific discoveries helped reveal new details about the inner workings of the Earth. At the same time, he was a dedicated member of the Jackson School of Geosciences faculty, supporting students and colleagues alike.

One of the most well-known images of the Earth's interior depicts the subduction of the Farallon Plate, an ancient oceanic slab, beneath the North American Plate as it dips down into the lower reaches of Earth's mantle. The image was produced by seismic tomography—a technology that uses seismic waves generated by earthquakes to reveal features of the Earth's interior in a manner akin to a medical CT scan.

The plate's journey to the deepest depths of the mantle came together into a discernable image thanks in part to the careful analysis and interpretation of Stephen Grand, a professor emeritus at the Jackson School.

The image—which appeared on the 1997 cover of *GSA Today*, the monthly magazine of the Geological Society of America—helped settle a big debate about whether subducted plates were confined to the upper part of the mantle or could circulate throughout the entire layer. It did so by showing two tomographical renderings, one created by Grand, the other by colleague Rob van der Hilst of the Massachusetts Institute of Technology. Together, the renderings presented clear evidence that the Farallon Slab was passing though most of the mantle, perhaps even making it to the mantle-core boundary.

"Our independently derived images looked similar, and that had a big effect on the geophysics community," Grand said. "For the first time, slabs could clearly be seen descending into the deep mantle."

Grand has spent his career mapping the Earth's interior by discerning different structures and processes using seismic tomography, drawing on seismic data from around the world. Most of Grand's academic career has been spent in one place: the Department of Geological Sciences at The University of Texas at Austin (now the Department of Earth and Planetary Sciences). After 35 years at the department, Grand retired in August.

The American Geophysical Union recently recognized Grand's contributions to the field of seismic tomography by presenting him with the 2022 Inge Lehmann Medal, which honors a senior scientist for outstanding contributions to the understanding of the structure, composition and dynamics of the Earth's mantle and core. He is also an AGU fellow.

In addition to imaging the famous Farallon Slab, some of Grand's other notable research accomplishments include improving the understanding of mantle convection, and working with his doctoral student, Peter Nelson, to reveal that the Yellowstone supervolcano is powered by a plume rising from the core-mantle boundary beneath Baja California. Later research proved that the tilt of the plume as it rises is due to mantle convection.

Grand's research helped bring some of the most mysterious and inaccessible parts of the planet into view. Yet, looking back on his career, Grand admits that he had only a fuzzy idea of what he was doing when he decided to pursue a doctoral degree in geophysics in 1984. He enrolled as a graduate student at the California Institute of Technology because he had an undergraduate degree in physics from McGill University, a passion for mountains, and was interested in living on the West Coast.

An early research project introduced him to seismic tomography, and how seismogram "bumps" relate back to the inner workings of the planet.

"I found it really neat that as a student, I could actually look at waves that went deep in the Earth and say something new about the Earth's interior," said Grand. "After that, I got hooked on mapping out the interior of the Earth."

Luckily for Grand, the field of seismic tomography was just getting started. There were many opportunities for exploration.

"Our knowledge of the inside of the Earth then was that there's a crust, a mantle, a core—basically that was it. What we knew about the dynamics and composition of Earth was kind of an arm-waving cartoon," Grand said. "I got into trying to map out what was actually down there using seismic waves."

Grand's seismic data sometimes came from pre-existing networks but in many cases, he, along with postdocs and students, would set up their own stations for regional projects. This included networks in East China and Manchuria, Mexico, and a line of instruments stretching from West Texas to Utah.

continued on page 76

NEW FACES

Fred Beach
Director of Energy and Earth Resources Program

Fred Beach is the new director of the Energy and Earth Resources (EER) graduate program, a multidisciplinary master's program at the Jackson School of Geosciences where students conduct research at the intersection of energy, natural resources, finance, law, policy and engineering. Beach fills a space left by Richard Chuchla, who retired during the spring after successfully leading the program for seven years.

Beach holds a doctoral degree from The University of Texas at Austin's LBJ School of Public Affairs, a master's in physics from the Naval Postgraduate School, and a bachelor's in chemistry with a minor in nuclear engineering from the University of Oklahoma.

Since 2005, Beach has held a number of roles at UT. This includes serving as the associate director for energy and technology policy at the Energy Institute, and appointments at the Institute for Advanced Technology and the Center for International Energy and Environmental Policy. Beach has also taught energy and policy courses at the Cockrell School of Engineering, McCombs Business School and the LBJ School of Public Affairs.

Beach is no stranger to the EER program, having served for many years as a graduate mentor and member of its Graduate Studies Committee.

Prior to joining UT, Beach served for 25 years in the U.S. Navy, where he was a qualified submariner, naval aviator, surface warfare officer and acquisition professional. Since retiring from the Navy in 2003, he has continued to serve as a U.S. Navy consultant on defense-related topics.

Michael Young
Associate Dean for Research

In September 2023, Michael Young became the Jackson School of Geosciences' associate dean for research. The role was formerly filled by Professor David Mohrig, who has returned to research.

Young is a senior research scientist at the Bureau of Economic Geology and served as its associate director for environmental research from 2010 to 2020.

Prior to joining the bureau in 2010, Young helped lead Nevada's Desert Research Institute, serving as its deputy director and acting executive director. Young has also worked as a hydrogeologist and a research scientist in soil, water and environmental sciences at the University of Arizona and Georgia Tech.

Young is a productive scientist and proven leader. He has authored book chapters, developed software, and has more than 100 refereed publications. He is also one of the principal architects of the UT Bridging Barriers program Planet Texas 2050, an interdisciplinary UT research initiative that looks to Texas as a microcosm of the environmental problems facing the planet.

Young has served numerous national organizations in advisory, editorial and strategic planning capacities, including the National Academies, the U.S. Department of Energy and the American Geophysical Union. He is a fellow of the Geological Society of America and the Soil Science Society of America.

In addition to his role as associate dean for research, Young will continue to lead research efforts at the Bureau of Economic Geology, in particular the Comparing Electricity Options industrial consortium. (See page 41 for more information on the project.)

FROM PAGE 75 | Stephen Grand

According to Mark Cloos, a long-time colleague of Grand's and a professor emeritus in the department, Grand's range of insights about the inner Earth are a testament to his skill in data selection—from placing monitors, to deciding which earthquake events generated the most relevant seismic waves.

"Steve has the ability you need to zoom in on the details that are really important for the question at hand, so a lot of attention to detail," Cloos said. "But he's not a perfectionist. He gets things done, and he has certainly fostered that in his students to get them publishing on a fairly regular basis."

In addition to his own research and the research of his students, Grand has played an integral role in supporting the department as an academic entity, Cloos said. Grand served as department chair from 2009 to 2011. And he spent years co-teaching with Leon Long (now a professor emeritus in the department) GEO 303, the introductory geology course for nonmajors. In this role, Grand opened the door to geology for many students.

"He is the perfect colleague and always has been," Cloos said of Grand. "He has always been here to make the place go."

After a long career focused on the Earth's interior, Grand said that he is looking forward to spending some time indulging in activities at the surface. That includes travel, spending time with his kids and, if all goes well, learning to cook and garden.

NEW FACES

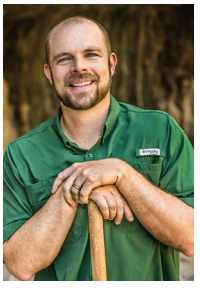
Miriam Barquero-Molina
Field Camp Director

Miriam Barquero-Molina is the new field camp director at the Department of Earth and Planetary Sciences. Before joining the Jackson School of Geosciences, she was the field camp director and an associate teaching professor at the University of Missouri for 13 years.

Barquero-Molina has experience leading field trips across the country, from California to the Appalachians, and has been at the helm of international trips to volcanoes in Chile, the Pyrenees and the Cantabrian Mountains in Spain. She also has direct experience of the Jackson School's own field camp. She earned a doctorate from the school in 2009 and helped lead field camp during her five years in graduate school.

Barquero-Molina fills a role left by Mark Helper, a distinguished lecturer emeritus in the department, who led field camp at the Jackson School for 34 years.

More on Barquero-Molina: ***www.jsg.utexas.edu/news/2023/04/jackson-school-welcomes-new-field-camp-director***

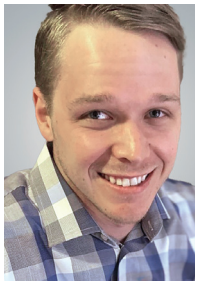


Kenneth Befus
Associate Professor of Professional Practice

Kenneth Befus is the director of the spectroscopy and imaging lab and the curator of gems and minerals in the Department of Earth and Planetary Sciences. Previously, Befus was an associate professor at Baylor University.

Befus earned a doctorate at the Jackson School of Geosciences, studying crystals in magmas and clues they hold about how volcanoes erupt. During his years at Baylor, Befus maintained his studies on magmatic systems, such as those at Yellowstone, but also started studying diamonds from the Amazon and metamorphic crystals from Argentina. He also started faceting gems at home, becoming a master faceter and selling stones to jewelers.

These dual, yet harmonious, interests have led Befus back to the Jackson School, with Befus' role in the spectroscopy and imaging lab aligning with his magma research and his role as the gem and mineral curator aligning with his expertise in gems and crystals.



David Bolton
Research Scientist Associate III

David "Chas" Bolton joined the Bureau of Economic Geology as a research scientist associate III, working with the Center for Injection and Seismicity Research and TexNet on induced seismicity. He is the lead investigator of an earthquake rupture machine, a device simulating small-scale earthquakes housed at the University of Texas Institute for Geophysics. His research broadly lies at the intersection of experimental rock mechanics and observational seismology and addresses problems such as earthquake nucleation, rupture, termination, foreshock sequences and poromechanics. Prior to joining the bureau, Bolton was a postdoctoral fellow at UTIG, where he worked to quantify spatiotemporal properties of foreshocks prior to slow and fast laboratory earthquakes.

Doug Hemingway
Research Associate

Doug Hemingway develops geophysical models to understand what makes the worlds of the solar system so different from one another. He's published studies of the interior structures of Saturn's icy ocean moons and a tantalizing finding that suggested Mars' long absent magnetic field may one day return. Before joining the University of Texas Institute for Geophysics, Hemingway was a space exploration industry professional and developed robotic servicing systems for the International Space Station and Hubble Space Telescope. Now a UTIG research associate, Hemingway continues to work on icy ocean moons and is investigating the magnetic histories of the moon and Mars.

Mohamed Shafik Khaled
Research Associate

Mohamed Shafik Khaled joined the Bureau of Economic Geology as a research associate in 2022 after completing a postdoctoral fellowship at UT's Hildebrand Department of Petroleum and Geosystems Engineering, where he studied the impact of heat management techniques in high-temperature geothermal wells. At the bureau, he focuses on developing high-resolution heat flow maps for fair resource evaluation, as well as optimizing geothermal subsurface engineering and power generation. He earned a doctoral degree in petroleum engineering from Texas A&M University and worked for Halliburton for over five years.

John Malito
Research Scientist Associate III

John Malito became a research scientist associate III for the Bureau of Economic Geology in 2022. In this position, he has been exploring ways to stabilize the water portfolio for Texas through aquifer storage and recovery and forecast-informed reservoir operations. He has also used a machine learning model to determine the drivers of health-based

water quality issues across the U.S. Before joining the bureau, Malito worked as an environmental specialist at a civil engineering firm. While completing his master's degree, he developed a sediment transport model to evaluate how climate-driven increases to wave erosion may shape future Arctic coastlines.

Tyson McKinney
Research Scientist Associate IV

Tyson McKinney joined the Bureau of Economic Geology as a research scientist associate IV in 2022. As a hydrogeologist, McKinney studies aquifer recharge. He is involved with a number of projects, such as measuring evapotranspiration across the Edwards Aquifer recharge zone, monitoring soil moisture in several regions across the state as part of the Texas Soil Observation Network, and investigating spring flow at several sites in West Texas. McKinney is also pursuing a doctoral degree from the Department of Earth and Planetary Sciences, and he has served as an instructor for GeoFORCE Texas.

Elizabeth Spiers
Research Associate

Elizabeth Spiers' research looks at the habitability and exploration of ocean worlds within the solar system. She joined the University of Texas Institute for Geophysics in 2023, where she is pursuing studies of ocean world interior system dynamics. The goal is to better understand how their aqueous environments change over time and the potential for those aqueous environments to support life. She also led a project under NASA JPL's Planetary Summer School, developing a concept study for a mission to Saturn's moon, Enceladus.

Danielle Touma
Research Associate

Combining climate observations with state-of-the-art computer simulations, Danielle Touma investigates the impact of global warming on wildfires, extreme rainfall and cascading climate hazards. Before joining the University of Texas Institute for Geophysics as a research associate in 2023, Touma was a postdoctoral fellow at the National Center for Atmospheric Research in Boulder, Colorado.

Tim Urban
Texas Space Grant Consortium Director

Tim Urban is director of NASA's Texas Space Grant Consortium, an outreach initiative to advance U.S. space science that became part of the University of Texas Institute for Geophysics in fall 2022 (see page 60). Urban has led Texas Space Grant since 2017, when the program was based at The University of Texas at Austin's Center for Space Research, but he has been involved since the 1990s. He has a doctoral degree in aerospace engineering from UT and has conducted research on sea level and ice sheet changes using satellite radar and laser altimetry.

Carlos Uroza
Research Scientist Associate IV

Carlos Uroza is a senior geologist with more than 20 years of industry experience in oil and gas. He joined the Bureau of Economic Geology (Gulf Coast Carbon Center) as a research scientist associate IV in 2022. He focuses on site characterization for geological storage of carbon dioxide in the Gulf Coast area. His skills in subsurface evaluation apply well to research on CO_2 storage. Uroza plans to continue researching the field of carbon storage both domestically and internationally. He has been supporting the development of a national CO_2 storage atlas in Trinidad and Tobago.

Michael Wang
Research Scientist Associate II

Michael Wang has been promoted to a research scientist associate II for the Bureau of Economic Geology after three years as a research assistant. In this role, he helps researchers with software support, database management and IT support, and he is leading a gradual shift for researchers to use new technology. Before coming to the bureau, Wang worked for a gold mine laboratory in Australia and an oil laboratory in Houston. He completed a master's degree in neotectonics at the National Taiwan University and studied potential natural hazards.

Mosher Joins Hall of Distinction

Sharon Mosher, dean emeritus of the Jackson School of Geosciences, was inducted into the Jackson School Hall of Distinction in spring 2023.

The Hall of Distinction is one of the Jackson School's top honors. It recognizes individuals with a strong affiliation with the school for accomplishments in academia, industry or government.

"I can think of no one worthier for this accomplishment," said Dean Claudia Mora, who inducted Mosher into the hall during the school's Evening of Thanks in March 2023, an annual event recognizing the school's donors and supporters.

Mosher, who is also a professor emeritus, became dean in 2009. She spent more than a decade in that role, helping to build the school into one of the top geosciences institutions in the world. Mosher helped unite the school's three diverse units – the Department of Geological Sciences (now the Department of Earth and Planetary Sciences), the Bureau of Economic Geology and the University of Texas Institute for Geophysics – under a shared identity as the Jackson School of Geosciences.

But Mosher's influence at The University of Texas at Austin began decades before she became dean. Mosher joined UT as an assistant professor in 1979 – the first female faculty member hired by the department. She ran the department's field camp for 15 years, taught structural geology to undergraduate and graduate students, and served as chair of the department from 2007 to 2009.

Mosher's scientific expertise is in structural geology, structural petrology and tectonics. Her primary research interests are in deformation along plate boundaries, the evolution of complexly deformed terranes, strain analysis, deformation mechanisms, and the interaction between chemical and physical processes during deformation. By her retirement in 2020, Mosher had supervised 35 master's, 18 doctoral, and nine undergraduate honors students, along with three postdoctoral fellows.

In addition to leading the Jackson School, Mosher has served as the head of several professional societies. She served as president of

the American Geosciences Institute from 2012 to 2013, president of the Geological Society of America from 2000 to 2001, and in 2004 as chair of the Council of Scientific Society Presidents, an organization that represents about 1.5 million scientists nationwide.

She also served as the founder and chair of the board for GeoScienceWorld, a nonprofit and online database that aggregates a range of peer-reviewed research from geosciences professional societies in one place. Along with strengthening cross-society collaboration and research, the database has returned more than $38 million to membership societies since it launched in 2005.

Since stepping down as dean in 2020, one of Mosher's biggest accomplishments has been to finish and publish "Vision and Change in the Geosciences: The Future of Undergraduate Geoscience Education." The report is the culmination of a multiyear effort, funded by the National Science Foundation, that she led to help align undergraduate geosciences education with the needs of the modern workforce. Mosher is now leading a similar project for graduate geosciences education (see page 13).

Mosher's induction into the Hall of Distinction adds to a long list of awards and accolades. This includes the Marcus Milling Legendary Geoscientist Medal from the American Geosciences Institute; the Alumni Achievement Award from her alma mater, the College of Liberal Arts at the University of Illinois at Urbana-Champaign; the Association of Women Geologists Outstanding Educator Award; and the Geological Society of America's Distinguished Service Award.

European Distinguished Geoscientist Medal Goes to Becker

The European Geosciences Union has awarded the 2023 Augustus Love Medal to Jackson School of Geosciences Professor Thorsten Becker for outstanding research contributions in the field of geodynamics and for leadership and selfless service to the scientific community.

The Love Medal is Europe's highest honor in geodynamics — the study of convection in Earth's solid mantle and of accompanying processes that shape the planet. The field includes plate tectonics, volcanism, mountain building and earthquakes.

"I'm happy to be honored this way and to be in the company of some really outstanding geodynamicists," Becker said.

Becker was among the first to use computer modeling to understand the pattern of flow in the mantle and its effect on the planet. In recent years, Becker has been part of several international efforts to understand large earthquakes, including the Megathrust Modeling Framework. Funded by the National Science Foundation, the project aims to use supercomputers to potentially forecast earthquakes in a manner similar to how they're used for forecasting weather.

Becker is a professor at the Jackson School's Department of Earth and Planetary Sciences and a senior research scientist at the University of Texas Institute for Geophysics. He is also an affiliated faculty member at The University of Texas at Austin Oden Institute for Computational Engineering & Sciences.

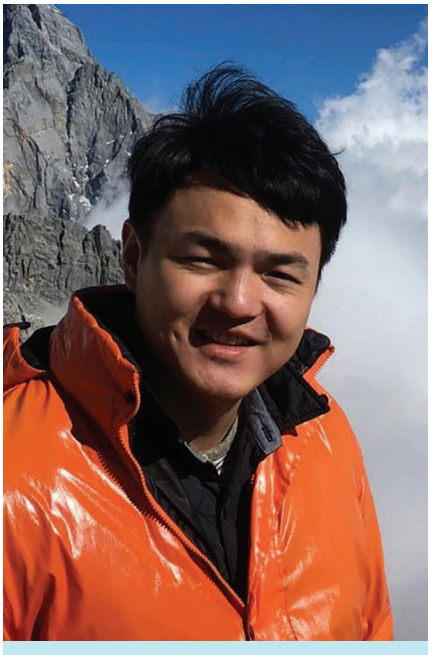
Banner Named Cherry Award Finalist

Professor Jay Banner has been named a finalist for Baylor University's 2024 Robert Foster Cherry Award for Great Teaching.

Banner, who is a member of the Department of Earth and Planetary Sciences and director of The University of Texas at Austin Environmental Science Institute, is one of three finalists for the prestigious teaching award. Each finalist receives $15,000, as well as $10,000 for their home departments to foster the development of teaching skills.

The finalists will present a series of lectures at Baylor during fall 2023 and a Cherry Award lecture on their home campuses.

The winning professor will be announced by Baylor in spring 2024 and be honored with $250,000 and an additional $25,000 for his or her home department in addition to teaching in residence at Baylor during fall 2024 or spring 2025.



Bureau Team Wins International Earthquake Forecasting Competition

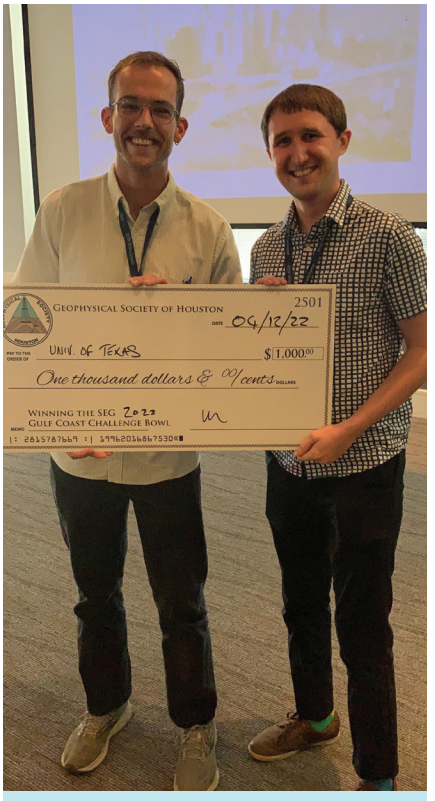
The Bureau of Economic Geology's Yangkang Chen led a team to win first place in the 2022 AETA Earthquake Prediction AI Algorithm Competition hosted by Peking University Shenzhen Graduate School in China, a competition that included 600 international teams.

Chen is a research associate at the bureau. His team included the bureau's Alexandros Savvaidis, Sergey Fomel, Dino Huang and researchers from other institutions. Chen's same team also landed second place in this competition in 2021.

Previously, research that leveraged AI techniques for precursory signal detection or earthquake prediction were all retrospective studies, meaning that investigations were based on historical data sets and models that could be tuned until the best-fitting performance was found. For the competition, the team conducted AI-based real-time earthquake prediction in both 2021 and 2022.

The team developed a data-driven model for predicting natural, destructive earthquakes (events equal to or greater than magnitude 3.5) in a specific geographic area based on AI and big data analysis. It applied the proposed data-driven model to a real-time earthquake prediction competition lasting two years and obtained a prediction accuracy of 70% in terms of earthquake occurrence, location and magnitude. The accuracy ranked second in the first year of the competition (2021) and first in its second year (2022). Chen said that the high score for consecutive two-year predictions among all participating teams indicates the effectiveness of the team's AI model.

This work is now published in a peer reviewed journal, see ***www.jsg.utexas.edu/news***.



Grad Students Win SEG Challenge Bowl World Final

Thanks to graduate students Edward Clennett and Ethan Conrad, The University of Texas at Austin is the reigning world champion of the Society of Exploration Geophysicists (SEG) Challenge Bowl.

The international competition tests the general geosciences knowledge of university teams from across the world. The world finals were held online in October 2022.

Clennett and Conrad are doctoral students at the Jackson School of Geosciences. Together, they brushed aside the competition, comfortably taking first place and the $1,000 cash prize with 158 points, 35 points clear of their nearest opponent, the National University of San Juan in Argentina.

It was the first time UT has been crowned SEG Challenge Bowl World Champion.

NSF Helping Matheny Take Water Monitor for Trees to Market

The National Science Foundation has selected Ashley Matheny, an assistant professor at the Jackson School of Geosciences, to take part in a national program that helps scientists gauge commercial interest and applications for their research.

Matheny is an ecohydrologist in the Department of Earth and Planetary Sciences. In 2021, she received an NSF Faculty Early Career Development Program (CAREER) Award to create a prototype sensor for gauging the water content of trees at different depths. The foundation's commercialization program – called Innovation Corps – will provide Matheny and her research team with $50,000 and expert support to investigate the market potential of these sensors.

"We're absolutely thrilled to take part," said Matheny. "It's a whole new adventure from what we usually work on in my ecohydrology research lab."

Suvan Cabraal, a doctoral candidate at the Jackson School, will serve as the entrepreneurial lead on the team. Sara Mitran, a mentor with the Texas Venture Mentoring Service, will serve as the industry mentor.

Top Petroleum Geology Award Goes to Milliken

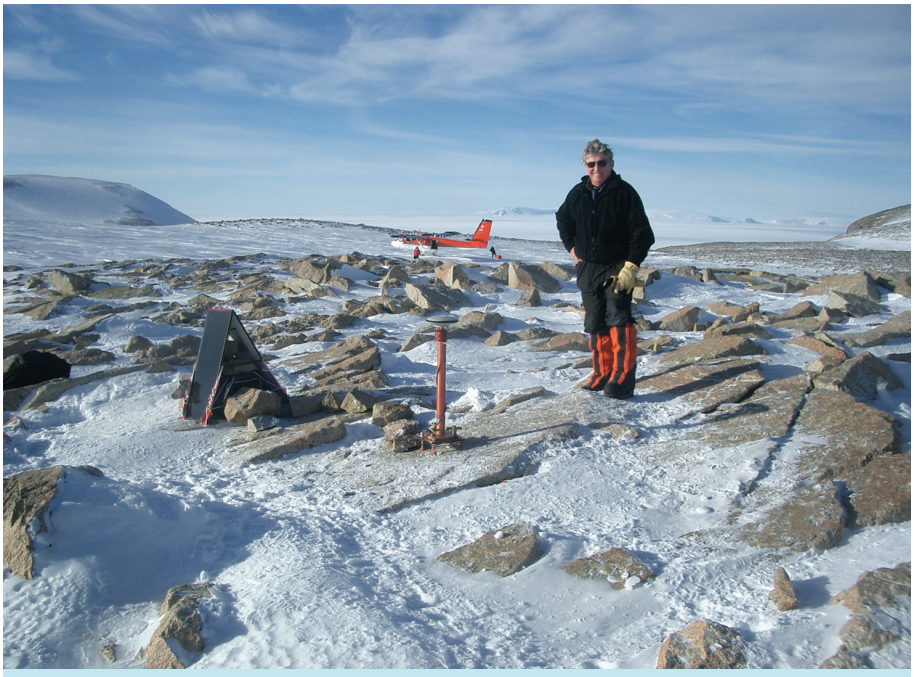
Kitty Milliken, a senior research scientist at the Bureau of Economic Geology, is the recipient of the Sydney Power's Memorial Award in petroleum geology, the American Association of Petroleum Geologists (AAPG)'s most distinguished award.

Milliken is the award's 76th recipient and the first woman to receive the honor. The award was presented at the AAPG's International Meeting for Applied Geoscience & Energy.

Milliken is known across the oil and gas industry for her work in sedimentary geology and the evolution of rock properties in the subsurface. Her research has shaped major energy production efforts and she has sailed on five major scientific ocean drilling expeditions. She also served as president of the Society for Sedimentary Geology.

Milliken said that the award was an acknowledgement of her work with AAPG and its influence on her.

"In a way, it's my field of study that is being acknowledged here and I love that," she said. "It means a lot, not just to me, but to my mentors and fellow petrographers who've always kept faith with the notion that it's important to look closely at the rocks."



Highest Honor in Antarctic Exploration Goes to Ian Dalziel

Ian Dalziel has been honored with the Polar Medal — the United Kingdom's top award for polar exploration. The medal recognizes Dalziel's contributions to Antarctic geology, including discoveries about the icy continent's ancient past and the fragility of its ice sheet today. The award was presented by Princess Anne at Buckingham Palace in October 2023.

The medal has existed for more than 150 years. Early recipients include pioneers of polar exploration Capt. R.F. Scott and Sir Ernest Shackleton, who made the first attempt to reach the South Pole in 1902. Dalziel's medal comes just two years after he received the Geological Society of America's Penrose Medal, widely considered to be the world's most prestigious career award in geology.

"This medal is about more than just Ian's status as an exceptional scientist. It's about the spirit of exploration that Ian imprinted on the scientific community and the institute where he has worked at for over 35 years," said Demian Saffer, director of the University of Texas Institute for Geophysics, where Dalziel works as senior research scientist.

Dalziel, who is also a professor in the Department of Earth and Planetary Sciences, was born in Scotland but spent most of his career in the U.S. and holds dual U.S.-U.K. citizenship. He has led several important joint U.S.-U.K. research efforts in Antarctica with scientists of the British Antarctic Survey. These include an investigation of South Georgia, a remote sub-Antarctic island. The research revealed that the island is in fact a lost fragment of the southern Andes in South America.

Dalziel's scientific endeavors have changed the way Antarctica is studied. He established the first GPS receiver network across West Antarctica, which led to the discovery that the continent is rapidly rising as its ice sheet melts away. The network is now part of a global network for observing the polar regions.

Dalziel also helped devise a logistical system — widely in use today — that uses U.K. Twin Otter and U.S. LC-130 Hercules aircraft to extend the reach of remote Antarctic research bases. Among its accomplishments, the system enabled the field work that confirmed that West Antarctica is a mosaic of fragments left over from the breakup of the supercontinent Gondwana. Working with international colleagues, Dalziel later demonstrated that El Paso in West Texas was probably once a neighbor to Antarctica's Coats Land.

Other Antarctic achievements include being among the first to explore the geologic setting of the "doomsday" Thwaites Glacier and leading a seminal expedition that set off a wave of scientific research into Earth's past supercontinents.

"Like many British kids, I'd grown up on a diet of Scott, Shackleton and [Edmund] Hillary and was intrigued by Antarctica and the Scotia Arc," Dalziel said. "But [pioneering geologist] Arthur Holmes and the way he looked at the world inspired me to look over the horizon and make connections that other people hadn't made."

The director of the British Antarctic Survey, Professor Dame Jane Francis, said that Dalziel's work had been fundamental to scientists' understanding of Antarctica, including its glaciation, the rise of its mountains, the origins of the Southern Ocean, and even the evolution of vegetation from Gondwana to Antarctica.

"Ian's medal is long overdue. Without his expertise and commitment to Antarctic geology over many years and many field seasons, we might still not understand fully the history of Antarctica in the past, which now helps us understand its future," she said.

Top Gulf Coast Geology Medal Goes to UTIG's John Snedden

John Snedden, a senior research scientist at the University of Texas Institute for Geophysics (UTIG), has been awarded the Don R. Boyd Medal for Excellence in Gulf Coast geology, the highest honor awarded by the Gulf Coast Association of Geological Societies.

The medal recognizes Snedden's contributions to the study of the Gulf of Mexico and his role in characterizing it as an energy super basin — one of a small number of prolific geologic basins that supply the bulk of the world's oil and gas.

"I am very humbled by this award from the association for my work in this wonderful Gulf of Mexico super basin," Snedden said.

Snedden is director of the Gulf Basin Depositional Synthesis program, a longstanding industry-funded research project at UTIG, whose geologic maps and research have helped identify reservoirs for exploration and provide important insights into the history of the basin's geology and climate.

Previous recipients of the Boyd Medal include William Fisher, former dean of the Jackson School of Geosciences, and Bureau of Economic Geology Director Scott Tinker. Both UTIG and the bureau are research units of the Jackson School.

Steve Grand Receives AGU Lehmann Medal

Professor Stephen Grand was awarded the 2022 Inge Lehmann Medal by the American Geophysical Union. The prestigious medal recognizes outstanding contributions to the understanding of the structure, composition and dynamics of Earth's mantle and core. Grand joined The University of Texas at Austin in 1986. His research has focused on seismically imaging Earth's mantle. This has included an effort to develop a 3D image of shear velocity throughout the mantle, with the ultimate goal to determine the dynamics of flow in the mantle.

Grand became a professor emeritus in 2023 (see page 75).

Rempe Receives NSF CAREER Award

Jackson School of Geosciences Assistant Professor Daniella Rempe received a prestigious Faculty Early Career Development Program (CAREER) Award from the National Science Foundation.

Rempe is using the funding to expand a network of critical zone monitors throughout the semi-arid western United States and explore the links between field measurements and satellite data. The critical zone is located just below the Earth's surface. It's where trees root and surface water seeps into weathered bedrock.

"With this funding, we can build predictive capacity," said Rempe. "The Texas climate, for example, is extreme: We need to learn more about how factors like extreme temperatures or successive years of low rainfall can make a drought persist despite the arrival of rains. Measurements below ground are needed to help us test our models."

Rempe is the third member of the Jackson School hydrogeological faculty to receive this award, following Bayani Cardenas in 2010 and Ashley Matheny in 2021. These awards provide five years of support to scientists who not only lead advances in their academic institution but serve as role models in both research and education.

Awards

Common Abbreviations:
AAPG ..... American Association of Petroleum Geologists
AGS ..... Austin Geological Society
AGU ..... American Geophysical Union
AMS.... American Meteorological Society
BEG ..... Bureau of Economic Geology
CPSH ..... Center for Planetary Systems Habitability
EPS..... Department of Earth and Planetary Sciences
GSA .....Geological Society of America
GSEC..... Graduate Student Executive Committee
JSG..... Jackson School of Geosciences
NSF.....National Science Foundation
SEG ..Society of Exploration Geophysicists
SEPM ....Society for Sedimentary Geology
UTIG..... Institute for Geophysics

FACULTY AND RESEARCHERS

BILL AMBROSE
Pioneer Award, AAPG

SAHAR BAKHSHIAN
Outstanding Educator Award, JSG

THORSTEN BECKER
Augustus Love Medal, European Geosciences Union
Outstanding Researcher, UTIG

DONALD BLANKENSHIP
Director's Circle of Excellence, UTIG

CAROLINE BRETON
Tinker Family Publication Award, BEG

DAVID CARR
Best Paper, AAPG Southwest Section

GINNY CATANIA
Director's Circle of Excellence, UTIG

YANGKANG CHEN
Winner, 2022 Earthquake Prediction AI Algorithm Competition, AETA

RICHARD CHUCHLA
Outstanding Educator Award, JSG

IAN DALZIEL
Polar Medal, United Kingdom
Career Award, UTIG

ROBIN DOMMISSE
GCAGS Journal President's Award, Gulf Coast Association of Geological Societies

SERGEY FOMEL
Winner, 2022 Earthquake Prediction AI Algorithm Competition, AETA
Audience Choice, EAGE Annual Hackathon, European Association of Geoscientists and Engineers

PETER FLEMINGS
Outstanding Research Award, JSG

JIM GARDNER
Knebel Undergraduate Teaching Award, EPS

JUN GE
Tinker Family Publication Award, BEG

TIM GOUDGE
Community Award, JSG

STEPHEN GRAND
Inge Lehmann Medal, AGU

SEAN GULICK
Director's Circle of Excellence, UTIG

SHUOSHUO HAN
Outstanding Researcher, UTIG

PETER HENNINGS
Tinker Family Publication Award, BEG

LILY HORNE
Best Recent Publication Award, AAPG Petroleum Structure and Geomechanics Division

BRIAN HORTON
Best Paper in Interpretation Award, SEG

SEYYED HOSSEINI
Tinker Family Publication Award, BEG

DINO HUANG
Winner, 2022 Earthquake Prediction AI Algorithm Competition, AETA

RICH KYLE
Hal Williams Hardinge Award, Society for Mining, Metallurgy & Exploration
AIME Mineral Industry Education Award, American Institute of Mining, Metallurgical, and Petroleum Engineers

STEPHEN LAUBACH
Joseph C. Walter Jr. Excellence Award, JSG

TIP MECKEL
Distinguished Lecturer, AAPG

KITTY MILLIKEN
Sidney Powers Memorial Award, AAPG
Robert H. Dott, Sr. Memorial Award, AAPG
Doris Malkin Curtis Medal, SEPM Gulf Coast Section

DAVID MOHRIG
Joseph C. Walter Jr. Excellence Award, JSG

SHARON MOSHER
Hall of Distinction, JSG

J.P. NICOT
Tinker Family Publication Award, BEG

DEV NIYOGI
Helmut E. Landsberg Award, AMS

YUKO OKUMURA
Director's Circle of Excellence, UTIG

CORNEL OLARIU
William R. Dickinson Award for Mid-Career Excellence in Sedimentary Geology, SEPM

CONNY RASMUSSEN
Outstanding Young Researcher, UTIG

DANIELLA REMPE
Faculty Early Career Development (CAREER), NSF

STEPHEN C. RUPPEL*
Charles J. Mankin Memorial Award, Association of American State Geologists
**Deceased at time of award.*

ALEXANDROS SAVVAIDIS
Winner, 2022 Earthquake Prediction AI Algorithm Competition, AETA

MRINAL SEN
Knebel Graduate Teaching Award, EPS

BRIDGET SCANLON
Rainmaker of the Year Award, BEG

JACK SHARP
Geology Dept. Alumni Achievement Award, University of Illinois Urbana-Champaign

KRISTA SODERLUND
Community Award, JSG
Director's Circle of Excellence, UTIG

KATIE SMYE
Tinker Family Publication Award, BEG

JOHN SNEDDEN
Don R. Boyd Medal for Excellence in Gulf Coast Geology, Gulf Coast Association of Geological Societies

LISA STOCKLI
Staff Service Award, EPS

ALEX SUN
Outstanding Research Award, JSG
Top Cited Article, Water Resources Research

SCOTT TINKER
President's Award, EnerGeo Alliance
Honorary Membership, Canadian Energy Geoscience Association
Boulos Lecture, Association of International Energy Negotiators

ALICE TURNER
Outstanding Student and PhD Candidate Presentation Award, European Geosciences Union

ADAM WOODHOUSE
Outstanding Postdoc, UTIG

PROMOTIONS

SHUVAJIT BHATTACHARYA
Research Scientist

ALEJANDRO CARDONA
Research Associate

MARC HESSE
Professor

ASHLEY MATHENY
Associate Professor

MARIA NIKOLINAKOU
Senior Research Scientist

DANIELLA REMPE
Associate Professor

KATHERINE ROMANAK
Senior Research Scientist

KATIE SMYE
Research Scientist

STUDENTS

JANA ALABDULLATIF
Runner-up, Master's Saturday Best Talk, EPS

TAUFIK AL AMIN
Pak Chuck Caughey Graduate Fellowship, JSG

OMAR ALAMOUDI
First Place, Late Career Award, JSG Student Research Symposium

RAWAN ALASAD
William Dow Hamm Memorial Grant, AAPG Foundation

JONATHAN AMENDOLA
Outstanding Academic Achievement Award, University of California, Santa Barbara

PATRICIA ASCANIO-PELLON
Master's Saturday Best Talk, EPS

WADE AUBIN
1st Place Graduate Student, R.L. Folk/E.F. McBride Petrography Contest, EPS

WILL BAILEY
Most Cited Article in 2021-2022, Sedimentology (Wiley)
Chateaubriand Fellowship, Embassy of France in the United States

EMILY BAMBER
Eugene and Carolyn Shoemaker Impact Cratering Award, GSA
Lunar and Planetary Science Conference Travel Grant, CPSH
Off Campus Research Award, JSG

LYNNA BENHAMOU
Biodiversity Scholars Award, UT College of Natural Sciences

SARAH BROOKER
Lipman Student Research Grants, GSA

MADISON CALLAN
Charlie and Eunice Haas Endowed Presidential Scholarship, UT
Austin Geological Society Scholarship, AGS
Texas Energy Council Scholarship, TEC
Honorable Mention, School of Undergraduate Studies Writing Flag Award, UT

MCKENZIE CARLSON
Donald D. Harrington Recruitment Fellowships, UT

COLE CARRABBA
Groundwater Field Methods Award – Undergraduate, EPS

KRISTIAN CHAN
Outstanding Graduate Student, UTIG
Ewing-Worzel Graduate Fellowship, UTIG
Outstanding Student and PhD Candidate Presentation Award, European Geosciences Union

EDWARD CLENNETT
Outstanding Teaching Assistant Award – Spring 2023, EPS
Ewing-Worzel Graduate Fellowship, UTIG
Challenge Bowl World Champion, SEG

ETHAN CONRAD
Outstanding Graduate Student, UTIG
William R. Muehlberger Graduate Fellowship in Structural Geology/ Tectonics, EPS
Best Graduate Student Paper, EPS
Challenge Bowl World Champion, SEG

SUSIE COOK
2nd Place Undergraduate Student, R.L. Folk/E.F. McBride Petrography Contest, EPS

NICOLE CZWAKIEL
GSEC Student Service Award, EPS

CAMERON DEFABRY
Groundwater Field Methods Award – Graduate, EPS

ARNAB DHARA
Ewing-Worzel Graduate Fellowship, UTIG

JACQUELINE EPPERSON
Student Research Grant, SEPM

LUIS CARLOS ESCOBAR ARENAS
Norman H. Foster Memorial Scholarship, Rocky Mountain Association of Geologists Foundation
Student Research Grant, SEPM

KYLE FOUKE
Second Place, Late Career Award, JSG Student Research Symposium

HUDSON FINLEY DAVIS
Geophysical Society of Houston/Hugh Hardy Scholarship, SEG

REBEKAH GARZA
Second Place, Undergraduate Students, JSG Student Research Symposium

ERIC HIATT
GSEC Student Service Award, EPS
Outstanding Teaching Assistant Award – Fall 2022, EPS
Ewing-Worzel Graduate Fellowship, UTIG

SCARLETTE HSIA
Outstanding Teaching Assistant Award – Fall 2022, EPS
Outstanding Teaching Assistant Award, National Association of Geoscience Teachers

CARA INGRAM
Geoscience IDEA Scholarship, Association for Women Geoscientists

SANDRA JUAREZ ZUNIGA
Don R. Boyd Memorial Grant, AAPG Foundation

MRITTIKA KABIR
EER Fellowship, JSG

HAZAL KIRIMLI
First Place, Early Career Award, JSG Student Research Symposium

RICHARD LARSON
Second Place, Early Career Award, JSG Student Research Symposium

GRACIELA LOPEZ CAMPOS
Ewing-Worzel Graduate Fellowship, UTIG
RAYMOND LUONG
3rd Place Undergraduate Student, R.L. Folk/E.F. McBride Petrography Contest, EPS

CAROLINE MACKIN
Texas Energy Council Scholarship, TEC

JOSHUA MALONE
Meckel Family Named Grant, AAPG Foundation

JACOB MARGOSHES
First Place, Undergraduate Students, JSG Student Research Symposium

JOHN MORETTI
Lundelius Endowment in Vertebrate Paleontology, JSG
Science Fund Award, Cleveland Grotto
Graduate Student Research Grant, GSA

EMILY MOORE
James and Ruth Harrison Scholarship, SEG

CARSON MILLER
Ewing-Worzel Graduate Fellowship, UTIG

IZZY MULLER
2nd Place Graduate Student, R.L. Folk/E.F. McBride Petrography Contest, EPS

JOSHUA MUNRO
College Recruitment Fellowship, UT

MARIEL NELSON
Reds Wolman Student Research Award, American Association of Geographers
Stanley A. Schumm Research Grant Award, GSA

WILL NGUYEN
Outstanding Teaching Assistant Award – Spring 2023, EPS

ASHER PIERCE
Undergraduate Prize, Mineralogical Society of America
1st Place Undergraduate Student, R.L. Folk/E.F. McBride Petrography Contest, EPS

MEDHA PRAKASH
Wilbur A. Nelson Award, University of Virginia

SEBASTIAN RAMIRO-RAMIREZ
Runner-up, Best Graduate Student Paper, EPS

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NICHOLAS REGIER
Off Campus Research Grant, JSG
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ADDISON SAVAGE
Groundwater Field Methods Award – Graduate, EPS

KAITLIN SCHAIBLE
Outstanding Student Presentation Award, AGU

LOGAN SCHMIDT
Outstanding Teaching Assistant Award – Spring 2023, EPS

KRISTIN SCOTT
Groundwater Field Methods Award – Undergraduate, EPS

SINJINI SINHA
Graduate Student Research Grant, GSA
Student Research Grant, Paleontological Society
Off Campus Research Grant, JSG

MICHAEL SNOOK
Estwing Hammer Award, EPS

PATTY STANDRING
Veteran's Memorial Scholarship, Rocky Mountain Association of Geologists Foundation
William V. Sliter Award, Cushman Foundation for Foraminiferal Research
Graduate Student Research Grant, GSA

TRAVIS STONE
3rd Place Graduate Student, R.L. Folk/E.F. McBride Petrography Contest, EPS

CLAIRE WILLIAMS
Ruth Gates Fellowship, Honorable Mention, International Coral Reef Society
Student Travel Grant, Conservation Paleobiology Network

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Dallas Geological Society Scholarship Endowment, Communities Foundation of Texas

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12TH ANNUAL STUDENT SYMPOSIUM WINNERS

The Jackson School of Geoscience's 12th Annual Student Research Symposium took place in February 2023 in San Jacinto Hall at The University of Texas at Austin. The research symposium is hosted by the Jackson School's Graduate Student Executive Committee and showcases the amazing array of research from across the school. The winners and honorable mentions are as follows:

HIGH SCHOOL STUDENTS

First Place: Shaunak Pandey: Pore-Scale Simulation of CO_2 Migration in Rough-Walled Geologic Fractures through Volume of Fluid Method leveraging High-Performance Computing for Risk Assessment of Carbon Sequestration.

Second Place: Mae Stone: Evaluating the Economic Value of the UT-0D0 Planet and the Habitability of the System.

UNDERGRADUATE STUDENTS

First Place: Jacob Margoshes: Bathymetric and Subsurface Character of the Mississippi Submarine Canyon.

Second Place: Rebekah Garza: Deep Respiration in a Semi-arid Juniper Oak-woodland and Implications for Coupled Carbon and Water Cycling.

EARLY CAREER AWARD

First Place: Hazal Kirimli: Quantification of Environmental Impacts Associated with the Full Life Cycle of the Global Nickel Supply Chain.

Second Place: Richard Larson: The Influence of Microscale Heterogeneity of Sedimentary Rocks on CO_2 Migration and Capillary Trapping in Geologic Carbon Sequestration.

LATE CAREER AWARD

First Place: Omar Alamoudi: Permeability and fracture evolution with confining pressure: an experimental study utilizing X-ray computed tomography and pulse-decay permeability measurements.

Second Place: Kyle Fouke: Assessing Complex Sea Level Instability and Environmental Change during the Last Interglacial: Insights from West Caicos, BWI.

BEST REPRESENTED RESEARCH GROUP

First Place: Cardenas Research Group

Second Place: Malkowski Research Group

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The Texas Leadership Society is composed of a distinguished group of friends and alumni who have included The University of Texas at Austin in their estate plans. Estate gifts support faculty and research, provide scholarships and graduate fellowships, and keep libraries, laboratories and facilities up to date. We would like to recognize those members who have designated the Jackson School as their beneficiary.

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The Flawn Circle of Excellence recognizes individuals who have given cumulative gifts of $1 million or more. Established in 2014, this society is named after Peter T. Flawn, former president of The University of Texas at Austin, professor emeritus at the Jackson School of Geosciences and lifetime member of the Geology Foundation Advisory Council.

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1940s

Bub Joyce (B.S. '48) writes, "After 73 years working as a petroleum geologist, I have retired and I am enjoying my new life of leisure."

1950s

Richard T. Buffler (B.S. '59) shares "We continue to enjoy living in Santa Fe and still traveling some. Come see us."

Wayne D. Miller (M.A. '57) says, "After working the past 65 years in the West Texas Permian Basin as a geologist for various oil companies and as an independent consultant for the last 40 years, I am finally slowing down. I still enjoy my morning coffee group with retired geologists and then spending time at my office. Still doing some consulting. Looking forward to the newsletter."

James V. Richards (B.S. '56) James V. "Jim" Richards is still living in Houston, Texas at age 89 after working over 60 years in the exploration business. He served as a longtime Delegate to AAPG, member of HGS, Treasurer of SIPES. Retired as a Commander USN.

Theodore E. Stanzel (B.S. '56) shares, "There is no significant news to report, however, living out my retirement years in Schulenburg among friends and relatives visiting from near and far."

Leslie P. White (B.S. '56) writes, "Dianne's Parkinson's worsened and we finally did what we had to do. We have vacated a home we have lived in 29 years and moved into a senior living facility. Dianne is doing very well here. She has many friends and attends every exercise activity available. I am busy as her caregiver. It is a job I cherish. The family is very happy to see the teaching and research that is happening at the outdoor learning center. And, as always, we are very proud of the achievements of JSG."

1960s

Rubin A. Schultz (B.S. '61) says, "Not much new, enjoying great grandkids and still traveling some. Nancy and I celebrated our 50th wedding anniversary on July 7, 2023."

Richard B. Waitt (B.S. '66, M.A. '70) shares, "I continue as a research geologist (not yet retired) with the US Geological Survey's Cascades Volcano Observatory at Vancouver, Wash. Finishing a number of Quaternary and physical-volcanology reports resulting from past and/or continuing fieldwork---mostly on recently erupted volcanoes such as Mount St. Helens and on the great Pleistocene Missoula floods. Lately edited and contributed to a GSA Special Paper 548 "Untangling the Quaternary" and led a fall-2021 GSA fieldtrip to upper Grand Coulee. I continue as an Assoc Editor for journals GSA Bulletin and Northwest Science. Through GSA Foundation, Cynthia and I are funding an annual student-research grant/award to support field-based research in Quaternary geology and physical volcanology."

William (Feather) Wilson (B.S. '60, M.A. '62) writes, "I'm still working as a consulting geologist at the age of 89 in the fields of petroleum and groundwater geology. My long journey as a frontier geologist allowed me to work in 67 countries both onshore and offshore for both major and independent companies in leadership roles from exploration and research to corporate officer. Published three books including two novels and many papers. Worked as a rancher, stockbroker, real estate broker, writer and a few other things but always came back to geology. I also have two sons who were UT Austin geology students who have now retired, Douglas and Clayton. I owe a great deal of my life as a geologist to my graduate advisor, Dr. R. L. Folk. It has been a wild ride!"

William C. Young (B.A. '61) says, "I'm still able to travel and see parts of the world, in spite of my hearing loss and diminished eyesight."

1970s

Gale Arden Bishop (Ph.D. '71) continues research on fossilized sea turtle nests from the Cretaceous Western Interior Seaway in Colorado and the coastline of Croatia. His team has identified 41 fossil nests in the Late Albian rocks near Pula, Croatia, on the shoreline of the Adriatic Sea. The fossilized sea turtle nests are tied directly to a sea turtle nesting ethogram and interspersed with tracks and trackways of dinosaurs, birds, Crocodilians, pterosaurs, and other Early Cretaceous beasts; with four nests actually stepped and tracked by dinosaurs. The Pula deposit is especially important as it represents a sea turtle rookery. Bishop's Research Team has thus far published six papers on the two occurrences.

Thomas W. Broadhead (M.A. '75) retired from the University of Tennessee (the other UT) in 2021 as Professor of Geology. In his 42 years at UT, he was director of the University Honors Program for nine years and later was Director of Undergraduate Academic Advancement, where he was involved in the recruitment of high achieving undergraduate students. A lifelong philatelist, Tom was named Outstanding Topical Philatelist by the American Topical Association in 2023 for his many related activities, including teaching courses about the historic and

cultural importance of stamp images for the UT Honors Program and at universities in China. Tom chairs the advisory board for the McClung Museum of Natural History and Culture at UT. He enjoys spending time with his grown children and five grandchildren.

C. Elmo Brown (B.A. '76) writes, "Not much new here in Kerrville (except for a lot of new houses). Kathy and I are enjoying our days living in the hill country. We did, however, take an almost month-long trip to enjoy the cuisine and nightlife of Portugal, the grand mosques and cathedrals of Spain and the scenic and rugged beauty of Morocco. The intertwined history of these three countries was quite interesting. Speaking of rugged beauty, we have also been spending a fair amount of time at our family place in the Big Bend country. It is the same house where, during spring break 44 years ago, 22 or so members of the University Student Geological Society (the UT geology club) spent a few days exploring the rocks of Big Bend; in part led by professor Bill Muehlberger."

Royce P. Carr (B.S. '76) writes, "Hi UT JSG Grads. Deborah and I still live in Mount Pleasant, Texas. We live on the lake and we have 3 sons and daughter-in-laws and five grandchildren. We travel and enjoy seeing family and friends. I hope to see you in Austin this fall. Hook'em."

Henry S. Chafetz (Ph.D. '70) says, "Hi all, been quite a while since I posted and a very long while since I graduated, 1970. Retired May 2020, Emeritus status at the University of Houston, i.e., still have an office and some lab space. It was a great run for me, UH paid me a salary for 50 years to play with carbonate rocks, which I'm still doing with a few former as well as present grad students. Had an interesting consulting gig recently as part of a large group pertaining to preservation of the Alamo, carbonate building stones have been in place 300 years, how can that be maintained. So still in Houston, enjoying the good life and would be more than happy to meet with any of my old classmates who happen to be in Houston and swap lies with them over a glass of beer, wine, scotch, whatever. Briefly, Janet, former wife, we married in 1969, passed away from cancer in 2006, was also UH faculty in Sociology; she published 11 books during her career. I remarried (Tralee) in 2015. Josh, my son, Yale undergrad and law school, with a M.Phil and D.Phil from Oxford as a Rhodes Scholar. He now has an endowed chair at Georgetown Law School. So life has had its ups and downs, but all in all, life has been good, could not imagine a better life for me than as a university prof."

Patricia W. Dickerson (B.A. '70, Ph.D. '95) shares, "Field work in the Big Bend continues with gusto, and with visible results. Sessions in Big Bend Ranch State Park with close colleagues yielded intriguing data that have now been published in a GSA memoir. Good to see all that in print -- especially so, as my longtime field compadre, Blaine Hall, was able to see it before he departed for extraterrestrial field research. 2023 began in the field on an exciting bi-national project (Chihuahua, San Angelo State, Sul Ross State universities) to investigate tectonic/hydrogeologic relations along the Rio Grande in Chihuahua. And on the horizon are page proofs of a chapter in an Elsevier text on world rifts. Still traveling -- excited about an IGCP 735 Task Force field conference in September 2024. We'll meet in western Argentina, in the area that started me on my current research path decades ago. It will be great grins to be back there with old friends and new data to show. (Of course, I'll build in time to tango in Buenos Aires, before and afterward!) Meanwhile, in this hemisphere -- and a year sooner -- I've just been asked to work another Smithsonian tour in Iceland this September -- looking forward to that! Hoping to get a (respectfully) closer view of the young volcano that's been blasting for some months, just south of the capitol. Here in River City, a mere city bus ride away, ongoing GeoRef work with favorite folks at AGI and UT is edifying and enjoyable. And volunteering for Austin Classical Guitar provides the musical accompaniment for it all."

Win R. Goter (M.A. '74) writes, "I have been retired for seven years and always surprised at how quickly those years have gone. Linda and I enjoy traveling with two years off for Covid and now trying to make up for lost time. A big focus for us is our five grandkids - four girls and one boy, with two daughters. I am outnumbered! Best wishes to all my fellow grads. P.S. I am on Facebook."

Paul F. Hoffman (B.S. '75) says, "Warm regards to all our long-time UT Geologist friends. I'm now nearly retired, but so grateful to UT and many mentors for making possible such a fulfilling career. Will likely dissolve Allen-Hoffman Exploration Co. this year, but still have some activity, both within AHEC and with some equity interests to keep me occupied. And doing some limited consulting. Concluding a 3-year term on the AAPG AC that was occasionally satisfying, but often exasperating. The recent AAPG leadership election does give me hope! I'm very active in several civic, professional, and church functions and trying to stay fit enough for racing the sailboat and pickleball - and wondering if I might again find time for golf. Tina and I settled in on the shore of Lake Livingston and are still in good health and keeping up with our kids and 16 grandchildren. And finally again enjoying lots of travel, both in the States and in Europe. Life's good!"

David M. Levin (B.A. '78) shares, "I found a place finally where I can beat the Texas summer heat: The Oregon Coast. Alaskan winds keep it cool

around 65 degrees all summer long.

I still have production and development to do but that is surprisingly difficult to get done from the beach in Oregon!"

Clair R. Ossian (Ph.D. '74) writes, "As I approach 83 years old, life has become greatly complicated. Unfortunately, my legs have suffered enough that I can no longer walk very well. So much for a wild life of climbing, exploring, and rich possibilities worldwide. It's hard to imagine the way my life would have turned out without having gotten my PhD degree from Austin. I can look back on a life that I could never have imagined. Thank you, Geoscience department, all the great profs, and a wonderful set of friends made during my grad years (1970-1974). I'd do it all again if I could."

Brendan L. Sidereas (B.S. '74) shares, "It's hard to believe, but I've been retired over 9 years now. Enjoyed a recent trip to much cooler Ontario, Canada. Stayed at a friend's family lakeside cottage near Westport. Visited Perth, on the fringe of the Canadian Shield, and their capital city Ottawa. Picked up some large crystals of feldspar and bought a very nice specimen of green and blue apatite with sheets of mica (economically mined). I do this rock collecting frequently on vacations now while my wife Carolyn shops. We'll be married 50 years Oct 2024, so it must work out well!"

1980s

Teresa M. Carpenter (B.S. '85) writes, "Does anyone wonder what a UT Geophysics student who graduates during a drop in the oil market does? Well, I got another degree in mathematics, then became a computer programmer for the Water Development Board. I then did the "dot com shuffle" as a website developer at various startup companies. During that time, I went to massage therapy school and coached soccer and volleyball on the side. After getting laid off when my position was eliminated, I started my own massage therapy and fitness training business using the same analytical skills I learned from my fields of study. Several years ago I added realtor and now broker to my list of careers, and love the variety! Through it all I'm still a rock hound, and my husband and I own a small ski condo at Purgatory resort outside of Durango, Colorado (where I spent 3 weeks mapping the area during GEO 660 field camp)." Teresa can be reached at tcarpenter512@gmail.com.

Daryl S. Chicken (B.S. '88) shares, "Working at Rival Downhole Tools selling drilling equipment to various operators around Texas. Two daughters: one getting her Masters at Trinity College in Dublin, Ireland and the youngest into her second semester at UT Communications." Daryl can be reached at daryl.chicken@icloud.com.

John L. Ebach (B.S. '82) writes, "Retired from Hess now, just enjoying life and cruising on Royal Caribbean when we can. I have more time to create fountain pens and other things that I want to try. Janet and I are still living in Kingwood/Houston, Texas. Hope renews every year for a football team to match our early 80's teams. To all the Geo 660 friends, Hook 'em Horns. All the grand kiddos are either in their last years of college or graduated. My oldest daughter still talks about the fun we all had in the thin section labs." John can be reached at johnebach007@gmail.com.

Tatiana Frierson (B.S. '85) shares, "I just had my 4th work anniversary as CEO of Inspirus (a Sodexo Company, benefits and rewards division). We are an employee engagement and recognition company that offers a global platform to recognize and retain our most important asset -- your people. It's been a great opportunity and have enjoyed doing "good" for employees and companies. Sodexo Benefits and Rewards has now been rebranded Pluxee -- and in 2024 we'll be spinning off from mother Sodexo and Pluxee will be listed on the Paris exchange. Lots of great stuff... Hook 'em Horns!"

Charles A. Goebel (B.S. '80) says, "I'm largely retired and enjoying life in Ft. Worth."

Paul A. Hardwick (B.S. '83) writes, "Still working at Smith Energy Company in Houston drilling conventional wells in the Northern Midland Basin. Coming up on our 39th wedding anniversary in September with my wife and UT grad Laurie. Proud of two daughters that graduated from UT. One with a Bachelor's living in LA and one with a Master's from LBJ living in North Carolina. Taking lots of trips and enjoying life. Hi to all the '83 grads."

Charles G. Johnson (B.S. '83) shares, "Now in my 40th year after graduation in the Centennial Year, I continue to pursue opportunities for acquisition, but successful ventures are harder to find when it comes to old conventional properties. Still, I am with

the same company now for the last nearly 28 years and have done extremely well, considering the ups and downs of our industry. Our baby girl has now graduated and heads off to yell "Roll Tide" in the fall of '23. I already have my tickets to the UT-Bama game in September and will definitely have my Burnt Orange fishing shirt on in the Visitors section, just not sure what hat I'll be wearing since a lot of our money is heading for Tuscaloosa. My two girls are still close, but I have sons in Japan and Prague teaching English and another with his family and our grandbabies in Eugene, Oregon."

Marcus M. Key (B.S. '83) writes, "It's been 40 years since graduating from UT! Maria and I are still living in Carlisle, PA where I work at Dickinson College. Our 5 kids are all grown and pretty much left the nest. Teaching soft rock geology classes and research keep me busy. I'm on sabbatical this academic year chasing bryozoans fouling sea turtles along the Atlantic coast and on Miocene crabs in eastern Europe."

Bruno Maldonado (B.S. '82) shares, "I am still ticking and find it difficult to retire as my love for geology keeps me involved in the local and national geoscience organizations. I keep telling Patricia that as long as someone has use for my skills I will continue to work as I see applying geoscience knowledge and technology as a passion. My current projects in Texas are keeping me state side and near my grandkids. As for one of my other passions, fishing, I have a dedicated understudy in Isaac, my grandson, who loves fishing. My three granddaughters are coming around and have fished some with me. In a recent fishing trip to the Galveston northern jetty Isaac caught a 38" bull red. I caught a 37.5" black drum. I am including some photos of this trip with my two sons and Isaac. As I mentioned above, I am not ready to retire, however, I am preparing for it as I am currently building my retirement dream home on acreage with a stocked pond (for the grandkids) in Hockley, Texas. That is all for now and hope to see you at the upcoming 2023 IMAGE Conference in Houston."

James P. McLaren (M.A. '84) says, "I worked in California from '84 to '96 making computer models of earthquakes to predict shaking, and to identify Russian nuclear tests. Returned to Austin in '96 and moved into Linux administration and system programming. Nora and I had one son, Tom, who got an M.S. in Biology from the University of Colorado. He just got married to the lovely Thea, and moved to Oregon. Sadly, Nora passed away late in 2022."

Ginger A. Miller (B.S. '87) writes, "After almost 30 years living out of state, 23 in Colorado, we have finally made it back to Texas as mostly empty nesters. We have settled on our little ranch (sadly no mineral rights) in Washington County. Brenham is our new hometown, and we are 6.7 miles from Blue Bell Creameries. Anyone driving by on 290 on their way to Austin is welcome to stop by and say hi!" Ginger can be reached at Gmbras@aol.com.

Shannon E. Morrison (B.S. '82) says, "Took over a year to renovate the house and surroundings on the 11-acre property we bought south of Houston. We don't miss Houston traffic, crime, or politics, but we do miss the restaurants. Have had some Green Acres moments (I caught the zero-turn mower on fire) and some personal revelations (I'll keep those to myself!). Started prairie conservation this year - removing exotic pasture grass and restoring native grasses and flowers, had a bumper crop of Northern Cardinals and Eastern Bluebirds and have racoon- and squirrel-proofed the bird feeders. Still traveling - Malaysia last Fall, Europe this Summer. Grandsons all growing up - oldest got married in April, youngest starts 7th grade in the Fall. Life is Good!"

Bruce R. Swartz (B.S. '82) writes, "I have phased out of being an Exploration and Operating Company and am concentrating on Prospecting and Consulting. Should have done this decades ago. I hope everyone is doing well."

1990s

Darcy B. Cuthill (B.S. '93) says, "All is well, living in Vancouver BC now with my husband and 3 teens, enjoying a new stage in life."

Bruce K. Darling (Ph.D. '97) shares, "I retired from my consulting practice in December 2021, but I remain involved with the profession in several ways. I am the District II (South Texas) representative for the Texas Section of the American Institute of Professional Geologists (TX-AIPG). In February 2023, I was a speaker at the 27th Annual Joint Engineering Societies Conference in Lafayette, Louisiana. The title of my presentation was "Differentiating between biogenic and thermogenic methane in groundwater"; and in April 2023, I led a three-day field trip to Hudspeth and Culberson counties, Texas for TX-AIPG. The field trip focused on the tectonic development, structural geology, economic geology (especially rare earth elements), and ground-water resources of that area of Trans-Pecos Texas. A key feature of the field trip was the drive on Day 2 to the highest point in the Eagle Mountains (Eagle Peak, elevation 7481 ft). In October 2022, Diane and I sold our house in Austin and moved to Bastrop, TX, ground-zero for the Darling family in Texas since 1834. Since the move, I have focused my time on rebuilding my ham radio shack and planning the installation of a rainwater collection system and the addition of solar power to both houses on our one-acre country 'estate.'" Bruce can be reached at bkdarling@protonmail.com.

Rimas J. Gaizutis (B.S. '91) says, "I just crossed my 10 year mark at Repsol as Global Subsurface Data Manager in the Woodlands and my twins start their senior year of high school."

Mark J. Graebner (Ph.D. '91) Mark can be reached at graebner@sbcglobal.net.

Dan R. McConnell (B.S. '95) writes, "Like the Neil Young song 'Comes a Time,' there comes a time in a geoscience career where you are either retired or working for yourself. I can't retire yet, so I have been on my own since Nov 2021. It is great that UT Austin is out coring deeply buried gas hydrates at WR 313 in the GoM as I write this. I have some history with the discovery of those deposits, and it is close to my heart. For me, I am not doing much in gas hydrates anymore, but am finding work in deep sea marine minerals, both desktop studies and offshore gigs. I expect some geoscience work supporting offshore wind, too. Beth and I have two daughters with wedding dates on the near horizon, so I am properly incentivized and need to stay busy! We are all happy and healthy here. I send my best wishes to all my fellow UT geoscientists and their families. My landing page is www.geomarineresources.com. Hook 'Em!"

Christopher S. Swezey (M.A. '91, Ph.D. '97) says, "I am still employed as a Research Geologist with the U.S. Geological Survey in Reston, Virginia. At present, I am supervising a large project called the Glaciated Regions Geologic Mapping Project that encompasses a variety of Quaternary and bedrock geologic mapping activities at scales ranging from 1:24,000 to 1:500,000."

Jennifer W. Truax (B.S. '92) shares, "I still live in Rowlett, TX. Happily married for 27 years. Now working as a staff accountant in Allen, Texas. Went for another college degree in Accounting after my BS Geology from UT and my MS in Geochemistry from UTD. In December, celebrated my oldest getting her dual degree in Architecture and Architectural Engineering from UT. My youngest is starting his sophomore year in college. Enjoying life!"

2000s

Jaime Orlando Castillo (M.S. '00) writes, "Hello everyone. Specially, Class of Fall 2000."

Kelly J. Daniel (B.S. '04) was elected to the Pflugerville Independent School District's Board of Trustees, Place 5, in May 2023. Her term in office will expire in May 2025.

Danl M. Lewis (B.S. '09) says, "A lot has happened since I left the 40 acres nearly 15 years ago now. I went to graduate school and received a Master's in Oceanography, started full-time at Chevron and moved to Louisiana, worked in asset development and exploration (for nearly 10 years!), got married, traveled the world, and started our family. I only recently moved to Houston for a new assignment with Chevron working in Global Frontier Exploration and Appraisal in the Emerging Countries - Cyprus team on the Aphrodite project. So far it's been a great experience! My family and I are looking forward to our next adventure!"

Pamela R. Owen (Ph.D. '00) shares, "I am part of the team leading the revitalization of Texas Memorial Museum -- now Texas Science & Natural History Museum. The building has undergone significant renovations and updates that will improve the visitor experience, all accomplished during this past year. I have been working with a local museum exhibit planning and design team to create new exhibits focusing on deep time and Cretaceous West Texas (hint: the pterosaur Quetzalcoatlus won't be the only big skeleton in the Great Hall!). I look forward to welcoming folks back to the museum when we reopen in September!"

Claudia Rassi (Ph.D. '02) says, "Still living the dream that I dreamt at the beginning of my Ph.D. in 1999, which was to have a chance to stay and work in Brazil. It has been some 21 years with Chevron, 15 of which in Rio de Janeiro. Petroleum business here is very exciting and has its challenges and I would not want to trade."

2010s

Randy H. Caber (M.S. '10) After almost 4 years working with Amazon.com over three states including a short assignment in Australia, Randy has moved on and is currently a Senior Manager for Starbucks in their Technology group in a fully remote role. Randy resides in Albuquerque, New Mexico, but actively travels, hitting his 50th country visited this year (Ireland). Looking forward to more experiences. Hook 'Em Horns!

Darby Delane Lee (B.S. '19) shares, "I received my MBA from UT Austin in May 2023."

Phillip G. Levasseur (M.A. '12) writes, "In 2011 my wife, Jacquelyn, and I left Austin, Texas for Pittsburgh, Pennsylvania where I began my career with Cabot Oil & Gas Corporation in environmental and regulatory compliance where we successfully

developed the Marcellus Shale in northeast Pennsylvania. In October of 2022, I was promoted to Manager, Regulatory Compliance for the Permian Basin assets of Coterra Energy, which is the result of the merger between Cabot Oil & Gas and Cimarex Energy. During our tenure in Pittsburgh we had two children Gustav (2016) and Kathryn (2019), Jacquelyn earned her masters at Duquesne University, and we became heavily engaged in local government where I was elected to public office and lead significant municipal investments in our community to reduce combined sewer overflows to the headwaters of the Ohio River. I will end my class note with words of encouragement to my fellow alumni for them to become involved in their local communities if they haven't already done so because they can help constructively direct the policy discourse with their respective knowledge and energy."

Frank Leslie Morgan (B.S. '11) says, "I'm currently working as the VP of Geology at Century Natural Resources with primary focus in the Powder River Basin. My wife and I are enjoying living in Houston with our two dogs, Little Larry & Jovie. Just wishing it wasn't so hot all the time!"

Caroline Mary Nazworth (B.S. '17) shares, "We welcomed our first child and future Longhorn in May!"

Michelle R. Stocker (Ph.D. '13) has been awarded tenure with promotion to Associate Professor in Paleobiology at Virginia Tech starting in Fall 2023. Stocker leads a group studying the evolution of morphology across vertebrates, focusing on fossils from the Triassic Period, and incorporating the use of CT technology.

Kelsi R. Ustipak (M.S. '15) writes, "I am amazed that it's been 10 years since I moved to Austin and started graduate school with David Mohrig's group. I enjoyed a year of interning with Badley-Ashton and living near the White Oak Bayou inside the 610 Loop. We left Houston after braving the woes of The Downturn job market and returned to Minneapolis, MN. When I eventually became an entry-level geoscientist in the environmental consulting industry, I had to learn many new skills on-the-job: basics of contamination hydrogeology, soil logging for Phase 2 investigations, overseeing installation of subsurface municipal utilities, and sampling highly contaminated groundwater wells. Instead of discovering new prospects, I was mitigating spilled products. In 2021, I joined the Minnesota Department of Transportation as a hydrogeologist. I am part of the Contaminated Material Management Team in the Office of Environmental Stewardship. I manage contracts with environmental consultants to investigate contaminated soil and groundwater risks on road construction projects. Things are about to get busy with federal infrastructure investments! Whether it's bats, bees, invertebrates, invasive species, or asbestos - we have specialists to address it while improving infrastructure. My spouse Peter and I own a house in South Minneapolis and will celebrate our 9th wedding anniversary this August. Peter supervises the packaging staff at Surly Brewing Co, where he's worked for 6 years. Our Austin rescue dog, Bigby, is 10 years old, gray-in-the-whiskers, and slowing down. He doesn't know that we're getting a cat this week, which will spice things up! We have recently enjoyed table top games like Spirit Island and Wingspan, video games like Tears of the Kingdom, and growing my hobby of gardening and collecting native flower seeds."

Gabrielle Marie Varona (B.S. '19, M.S. '22) After graduating in December 2022, Abby started at ExxonMobil as a geoscientist. She is currently on the Guyana Exploration Team. She's had the opportunity to go through new hire trainings including the Big Horn Basin Workshop, learning about exploration concepts and how to apply them in the Guyana Basin.

2020s

Cole Laughlin Carrabba (B.S. '23) shares, "I am excited to start my career in August 2023 as a Staff Geologist I at ESE Partners, an environmental consulting firm based in Houston, Texas. I hope to eventually return to school for a graduate degree." Cole can be reached at colelcarrabba@gmail.com.

London Colette Darce (B.S. '22) says, "I got a job as a Recorder Program Specialist with the Texas Water Development Board's Groundwater Monitoring team! It's an awesome place to work located right here in Austin that's growing quickly and has upcoming job postings that are perfect for new grads." London can be reached at london.darce@twdb.texas.gov.

Daniel Anthony Floris (B.S. '23) can be reached at daniel@floris-us.com.

Kameel Jiries Kishek (M.S. '23) Kameel can be reached at kameelkishek@gmail.com.

Anurag Abhay Kulkarni (B.S. '23) says, "I've been on a round the world backpacking trip this summer as a victory lap for completing my degree. However, I've been doing a fair bit of geotourism as well. I've seen paired metamorphic belts in Japan, the large laccolith mount Kinabalu in Borneo, massive karst formations in Malaysia, Ophiolite in Borneo and Oman, and the Deccan traps basalt in India. A unique perspective on travel!"

Erica Lee McCormick (B.S. '20) writes, "I've finished the first year of my Ph.D. in Earth System Science at Stanford. It's been great living in California and enjoying the weather with my new puppy!"

Heather Rose (M.S. '20) is currently a Regional Water Planner for the Texas Water Development Board. She works with communities around Texas, guiding them with developing their regional water plans for future water supply. Heather also assists communities with applying for state funds to build and/or improve water infrastructure in their area. Heather currently works with Region E (El Paso, Marfa), Region F (San Angelo, Midland, Odessa), and Region H (Houston metro area). Feel free to contact Heather with any questions about working for the state. She can be reached at heather.rose@twdb.texas.gov.

Simon George Scarpetta (Ph.D. '21) recently finished his NSF PRFB at UC Berkeley and is starting a 1-year Assistant Professor position this fall semester at the University of San Francisco!

Marlowe Enrique Zamora (B.S. '20) graduated from St. Mary's School of Law and taking the bar exam soon!

FRIENDS/OTHER

William I. (Bill) Woods writes, "Now that Covid is more or less over and I have recovered from a health issue, Francisco and I are headed on our first vacation in three years. We look forward to spending time in Telluride, hiking and seeing the sights and staying a bit cooler. Although it was a rough year, I'm very happy to say that I continue to keep up with friends in DGS and enjoyed my visits at Mark Helper and Mark Cloos' retirement events, and while there seeing friends and those I worked with for many years. All the best to everyone!"

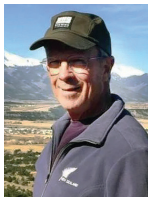
PROFESSORS EMERITI

James Sprinkle, Professor Emeritus, writes: "This was my 10th year of retirement, and G.K. and I spent most of the year cleaning my office so I could move to a new smaller office for Emeritus Professors on the 6th floor. So, this was the last year in my JSG 4.106 office. I inherited this office from Charlie Bell, who was also a paleontologist, who retired the year after I came to UT. His office was nearly perfect for me because one wall (N side) was lined with 12, 6-ft.-high, tiers of wooden specimen cabinets, which I slowly filled up with echinoderm and teaching specimens found during field work. Another wall (W side) had bookcases with floor-to-ceiling shelves, which I slowly filled up with journals, books, and slide trays for teaching. In the back of this office (E side) was a darkroom for developing pictures and slides that I and my students used to make plates for publications until about 1995. In the 1980s, another desk-to-ceiling bookcase was added above the back of my desk for books, and 57+ reprint boxes, which rapidly filled up with reprints from other echinoderm workers who studied similar topics.

Two wooden specimen cabinets went upstairs to my new office (6.114) with specimens that I needed to work on; the other 10 wooden cabinets were sent out to the Non-vertebrate Paleontological Laboratory (NPL) for storage in their new climate-controlled building at the Pickle Research Center (PRC). My new office also has my computer, a small printer, my microscope, three 4-door file cabinets with files for my former students, projects that needed completion, and topics that I used for teaching. Most of my reprint boxes, many of my journals, and many books were included using new bookcases or the original desk one. Lisa Boucher, Director of the NPL, helped with my remaining journals and books by combining them with the partly complete journals and books that the NPL already had in their library, so they were available for me and others to use."

Alumni

James B. Bennett (B.S. '61) of Houston, Texas, passed away peacefully on February 14, 2023. J.B. was born in Houston on January 5, 1935, to Mary Baxter Mauldin and James Vernon Pierce Bennett. J.B. spent many happy summers as a boy at his mother's family's farm in Leonard, Texas, in Fannin County. During the Second World War, J.B. and his mother lived in Oak Cliff in Dallas while working the assembly line at a defense plant in Grand Prairie, Texas, manufacturing military aircraft. J.B. and his mother moved to La Marque, Texas, when he was 13, where J.B. finished high school as a football and track athlete, competing in the Texas Relays in Austin. Following graduation from La Marque High School, J.B. attended The University of Texas at Austin. He interrupted his studies by joining the U.S. Army from 1957-1959 and was stationed in Europe. Following his honorable discharge, J.B. returned to Austin and finished his geology degree with help from Kathryn Giddens, a fellow geology major. Kathryn and J.B. married in 1961 and had a loving, devoted marriage for 43 years until her passing in 2004. J.B. began his professional career with Texas Eastern in Shreveport, Louisiana. In 1970, he moved to Houston with his wife and daughter to work for Champlin Oil and then Belco Petroleum. J.B. subsequently left the corporate world and became an independent geologist. After a partnership with Joe Precup, J.B. and Randy Schott formed B&S Exploration. They enjoyed a wonderful friendship as well as a successful partnership. They worked together for 32 years until J.B.'s retirement in 2018. J.B. was committed to his profession and, like all good geologists, knew how to weather the ups and downs of the oil and gas industry. He devoted much of his time to the Society of Independent Professional Earth Scientists (SIPES), having served as Chairman of the Houston Chapter and was awarded the SIPES Outstanding Service Award in 2000. J.B. was also active in the American Association of Petroleum Geologists, the Houston Geological Society, and the Gulf Coast Association of Geological Societies. Although he was an only child, extended family was important to him. J.B. is survived by his daughter Kathryne Bennett Hillier and husband Jeff Hillier; son Wiley Baxter Bennett and wife Margaret Riccetti Bennett; grandsons Travis Winters Hillier and wife Kate Marie Hillier, and Cameron James Hillier and wife Maggie Inhofe Hillier.



Edgar L. Berg (B.S. '67, M.A. '71), 78, died in Salida on Oct. 17, 2022. He was born June 17, 1944, in Baltimore, Maryland, to Edgar Hamlin Berg and Margaret "Peggy" Elizabeth Morton Berg. As a child, he developed his love of nature, boating in Barnegat Bay, New Jersey, swimming, and hiking in Montreat, North Carolina, his ancestral home. He earned his bachelor's and master's degrees in geology at The University of Texas at Austin. There, he met and married his wife, Paula Marie Dolman. They met on Monday, were engaged by Friday, and married seven months later. In his 40-plus-year career in petroleum geophysics, Mr. Berg worked on every continent in the world. When he retired to Salida in 2005, he began his heart's work in soil conservation, local food, poetry and music. Mr. Berg was a founding member of the board of AgriSummit and served 11 years on the Upper Arkansas Conservation District board. His family said his legacy is in more than his grandchildren: It is in his remarkable friendships and in all who loved him; it is in his faith in humanity's potential to again be in harmony with the earth. Mr. Berg was preceded in death by his parents. Survivors include his wife of 55 years; daughters, Rebecca Longberg, Beth Berg and Anne Pattillo; grandsons, Axel, Bodhi and Wilson; sister, Fran; brother, Charlie; and many nieces and nephews.

Thomas E. Bridge (Ph.D. '66) was born April 3, 1925, in Campo, Colorado, and died October 21, 2022, at Chase County Care and Rehabilitation Center in Cottonwood Falls, Kansas. Tom lived during the Dust Bowl days and the Depression. His father, Alfred Bridge, died when Tom was eight years old. Four years later, his mother Nettie married John Regnier, and they moved to Medicine Lodge, Kansas. He joined the Navy and served in World War II on islands in the Pacific. Upon returning, he married Syble Jane Watson after graduating from high school. Tom graduated from Kansas State University with a master's degree in geology in 1950. In 1966, he received his Ph.D. in geochemistry from the University of Texas. He held a variety of jobs in his career: elementary teacher in Keats, Kansas; high school principal in Agenda, Kansas; teacher at Colorado State University in Fort Collins, Colorado; teacher at Texas Tech in Lubbock, Texas; professor of geochemistry at Emporia State University until he retired in 1991. Upon retirement, Tom, Syble, and Annie, his daughter, traveled around the world. Tom's family was very important to him. He is survived by his wife, Syble Bridge, in Toledo Township; his daughters, Rebecca Carle, Lynn Ann Bridge, and Tammy Jo Hayes; his son, Michael Bridge; eight grandchildren and eight great-grandchildren.

James M. Cahal (B.A. '58), 92, of Marietta, passed away peacefully with his children and wife on July 17, 2023. James was born in Port Arthur, Texas, to Dave and Lula Cahal. He was one of eight children and leaves behind two surviving siblings: Jerold

Cahal and Tommy Cahal. James was known as "Buster, Jim, and Pops." He attended Stephen F. Austin State University and enlisted in the United States Air Force. After his service, he obtained his degree in geology at The University of Texas at Austin. Also, while serving in the Air Force, he met the love of his life, Frances Barnes Cahal. They were happily married just shy of 70 years. Jim's career spanned many years in chemical water treatment. He was a Christian, and his faith was reflected so much in his character. He attended Powers Ferry United Methodist Church and, in his later years, Mt. Bethel United Methodist Church. He was loved by all who met him, and his grandchildren were no exception. They loved their "Pops" for all he taught them and for the loving attention he gave each one of them. James is survived by his devoted wife, Frances Cahal; sons, James M. Cahal, Jr. (Marie), Allen Cahal (Colleen); and his daughter, Elizabeth Hyre (Rodney). He also leaves behind seven grandchildren and three great-grandchildren.

Steve K. Compton (B.S. '81), born in Denver City, Texas, and raised in Midland and McCamey, Steve Compton was a West Texas boy through and through. The lessons he learned from small-town living and working for his grandfather in the oil fields as a teen were life skills he carried with him. After his enlistment in the Marines, Steve earned a B.S. in Geology from the University of Texas and an M.S. in Applied Geophysics from the University of Houston. He worked with Pogo Producing Company and Tri-C Resources. One of his mentors at Pogo once commented that he had never seen someone who had worked the oilfield from the bottom to the Board Room. Those experiences led him to understand the entirety of the oil business that few possess. It served him well. Golf was always a passion, starting with his high school team winning State. For him, it wasn't about the longest drive or the newest equipment; golf for Steve was more about relationships than scoring. He enjoyed winning but reveled in the people he met through the years and their life stories. He collected friends the way he collected rocks: each one was discovered at a unique time and place, formed by different forces and capable of enduring the elements. He held fast to those friendships. But family was always first. He and Caroline had two children. With forethought and focus, Steve helped guide his children to their best selves, and in that, he succeeded beyond measure. Watching them grow to adulthood was his greatest pleasure and his proudest accomplishment. As Steve left this world, he was greeted with open, loving arms by his daughter, Katharine Elizabeth Compton, many friends, family, and his two bird dogs. Left behind to face life without Steve is his wife, Caroline Brown Compton; his son, Campbell Bennett Compton; his brother, Jim Compton; his sister, Beth Compton; and a legion of friends, all equipped with his love, wisdom, and bravery.

Jon C. Ehman (B.S. '60) passed away peacefully at home on Monday, Nov. 21, 2022, after a courageous battle with cancer and COPD. Jon was the third child born to the late George and Portia Cleaves Ehman on Sept. 28, 1937. Jon was born and raised in Houston, Texas, and also attended high school there. He married his best friend whom he cherished, Billie Townsend Ehman, on June 4, 1961, and shared 49 loving years together before her death in 2010. Jon received a Bachelor of Science in geology from The University of Texas at Austin and proudly served as a Lieutenant in the U.S. Navy. He worked in the oil and gas industry across the U.S. and called Lafayette home since 1983. Jon retired from Camco with over 30 years of service. Known as "Pops" by those who loved him dearly, he thoroughly enjoyed his retirement and watched all college sports, hunting, fishing, traveling, and spending time with family. Survivors: sons Keith Ehman of Lafayette and Rickey Bryan and wife Mary of Broaddus, Texas; grandson, Stoney Bryan and wife Melissa of Broaddus, Texas; a brother, James Ehman of Houston; as well as numerous nieces, nephews, and other relatives. He was preceded in death by his parents, wife, Billie; infant daughter, Sandra Kay; and a sister, Judith Funk.

William E. Gipson (B.A. '48, M.A. '49) passed away on Thursday, the 23rd of March, 2023, at 98. He was born in Winters, Texas, on the 6th of September 1924 in his grandparents' home on Church Street to William Francis Gipson and Martha Marguerite Edwards Gipson. His family moved to Gilmer, Texas, when he was a young boy, where he was raised and attended public school. He excelled at football in Gilmer High School, where he earned full athletic scholarships, and he went on to play fullback for Kilgore Junior College. After receiving an associate degree from Kilgore College, he entered Southern Methodist University, where he continued to play football. Bill's studies and football at SMU were interrupted in 1944 when he enlisted in the United States Navy. After graduating from US Navy Midshipman's School, he was commissioned as an Ensign. He was assigned to the USS LCS(L)-45, a Landing Craft Support amphibious warfare vessel, and he saw action in Borneo in June 1945. Later his ship was assigned to mine sweeping duty in various Pacific Ocean locations. After his honorable discharge from the Navy as a Lieutenant Junior Grade, Bill returned to Texas and entered The University of Texas at Austin. He earned his BA with Honors in 1948 and his MA in 1949, both in petroleum geology. Upon graduation, he began working for the Ohio Oil Company in Midland, Texas, before becoming an independent consulting geologist in the Texas oil and gas industry. Later he was recruited by the Pennzoil Company as Senior Vice President of Exploration, and in 1967, he moved to the company's headquarters in Houston, Texas. In

1977, Pennzoil spun off its wholly owned subsidiary, Pogo Producing Company, where he served as its President, COO and board member until his retirement. Bill pursued many interests and hobbies with passion throughout his long and productive life. He loved his family and many lifelong dear friends. In the early 1950, he bought a farm in east Texas outside of Gilmer where he raised timber and bred registered Santa Gertrudis cattle for the rest of his life. He was a member of several wine-tasting groups in Houston over the years. In the mid-1980s, Bill became an investor in and subsequently owned Pheasant Ridge Winery, one of Texas' premier wineries and vineyards in the AVA "Texas High Plains" near Lubbock. The winery produced world-class estate-grown Cabernets, Pinot Noirs, and Chablis until he sold the winery and vineyards by auction in 2013. Bill was an avid fly fisherman, fishing in Wyoming, Colorado, New Mexico, Canada, Argentina and elsewhere. He also enjoyed bird hunting in south Texas. He was a lifelong student of American history, and he loved reading and traveling the world. Over many years in Houston, he was a member of the All-American Wildcatter Association, a board member of the American Association of Petroleum Geologists (AAPG), the Houston Downtown YMCA, and the Houston Club, of which he was a past president. Bill was on the advisory committee of The University of Texas at Austin Jackson School of Geosciences, a booster of the SMU Mustang football team, and a member of the DeBakey Heart Institute Advisory Council at Houston Methodist Hospital, among many other organizations. He was a member of Church of St. John The Divine Episcopal church in Houston. Bill was preceded in death by his parents and his daughter, Elizabeth Anne Gipson Bird. His survivors include friend and partner, Mary Rinaldi; son, William Earl Gipson, Jr. of Fort Worth; daughters, Carolyn Gipson Allen of Austin and Judy Gipson Dean of Louisville; eleven grandchildren; numerous great-grandchildren; two great-great-grandchildren; and his cousins, E.F. Edwards of Fort Collins, Colorado and Dr. Jon Edwards of New York City, New York.

William R. Gumert (M.A. '68), 84, of Perkasie, died Tuesday, October 4, 2022, at Harborview Care and Rehab Center, Doylestown. He was the husband of Dolores (Sabo) Gumert for 48 years. Born in Houston, TX, he was the son of the late Thomas A. and Mary (Giltner) Gumert. Bill received his B.S. in Geology from Texas Tech University, Lubbock, and later earned his M.A. in Geology at The University of Texas at Austin. For many years, Bill was employed as the chief geophysicist in the airborne gravity field at Carson Helicopters, Hilltown. In addition to his wife, Mr. Gumert is survived by his son, Michael, of Singapore; his daughter, Andrea Robinson, and her husband, Casey, of Hoover, AL. He is also survived by four children from a previous marriage, along with their spouses: Cathy and Bill, both of central Pennsylvania, Lynn, of New Jersey, and Susan, of southern Maryland; several grandchildren and great-grandchildren. In addition to his parents, he is also preceded in death by his brother, John of Ingram, TX.

Henry R. Hamman (B.S. '60, M.A. '63) was born in Houston to Lenoir and John Hamman, Jr. on the 15th of June 1937 and passed away peacefully at his home in Houston on Thursday, the 11th of May 2023. He was 85 years of age. He attended St. John's School, The Lawrenceville School and The University of Texas at Austin, where he obtained Bachelor of Science and Master of Arts in Geology degrees. There, he also met his love and wife of 63 years, Ann Hamman. Henry was the president of Hamman Oil and Refining Company, a fourth-generation family-owned oil and gas exploration and production company with operations in Texas. He was proud to be a Texan and proud to be an independent oil man. As he said, his first time in the "oil patch" was in Calvert, Texas, working with his dad when he was a teenager, and after that, the oil field was in his blood. His love of Earth Sciences led him to a long-term and happy relationship with the Houston Museum of Natural Science, where he served as a Trustee and advisor for many decades. Henry was constantly curious and a lifelong learner. But his true intellectual love was geology. He supported the Jackson School of Geosciences through scholarships, programs, and the recently opened Henry R. and Ann H. Hamman Gem and Mineral Gallery in the Jackson Geology Building at The University of Texas at Austin. He was a member of the All-American Wildcatters Association, Society of Independent Professional Earth Scientists, and American Association of Petroleum Geologists. During his career he served as a director of Q Services, Pennzenergy and Devon Energy Corp. Henry was a fervent philanthropist and was president of the George and Mary Josephine Hamman Foundation for many years, issuing thousands of college scholarships and supporting numerous community organizations. He was an ardent conservationist and taught his family always to preserve the natural beauty of land. Following this passion for conservation, he became an Advisory Board member and later Chair of the Caesar Kleberg Wildlife Research Institute. He also held roles in the Matagorda Bay Foundation, Coastal Conservation Association, Texas Heart Institute and Retina Research Foundation. Henry never lost his innate adventurous spirit. Although his passion for quail hunting was always at the forefront locally, he and his family travelled extensively, exploring Asia, Europe, and Africa. In 1970, they settled in Sydney, Australia for four years, where Henry pursued mining and real estate opportunities. Henry's gregarious nature led him to become a part of the fabric of several social organizations in Houston, including the Bayou Club of Houston and River Oaks Country Club. Henry had an infectious sense of humor and always had a twinkle in his eye. He was kind, generous and charismatic - a lifelong friend to many who touched

more along the way with his quick wit and intellect. Henry was a true Texas gentleman. Henry Married Ann Hufendick in 1959, and they loved each other for over 63 years. Together Ann and Henry had three children and nine grandchildren. He was predeceased by his parents, John Hamman, Jr. and Lenoir Bowen Hamman, and his brothers, John Hamman III and William George Hamman. He is survived by his wife, Ann Hufendick Hamman; his daughters, Anne Hamman Brollier and her husband Stephen, Kendall Hamman Connors and her husband Michael; and son, Russell Royden Hamman and his wife Kelly; and nine grandchildren.

John D. Hine (B.A. '92), 67, passed away peacefully at home on Friday, March 3, 2023, in Spokane, Washington. He was born in Big Spring, Texas, to Donald and Regina Hine. He spent much of his youth there and was known to many as their paper boy. After graduating from Coronado High School in Lubbock, Texas, he studied Geology at the University of Texas and later completed his MBA in Marketing and Finance with LeTourneau University in 2004. After years of experience with HEB, he achieved his dream of owning multiple 7-Eleven franchises. John loved stock car racing and is remembered for the blue Chevy Nova II he built himself. He developed lifelong friendships on the circuit. John was an avid bicyclist, a member of the Austin Cycling Association, and a participant in organized bike races. He liked riding motorcycles as well. John loved cats; "Peter the Great" was his favorite and is remembered for feeding strays. John was preceded in death by his parents, his nephew, Donald Mark Slann, and his sister, Sheila Sue Hine. Survivors include his sisters Regina Campbell, Barbara Simpson, Constance Stout, Deborah Ross (Barry), and Mary Beth Peterson (Dennis).

Peter C. Keller (M.A. '74, Ph.D. '77), a charismatic adventurer, relentless collector, museum visionary, loyal friend, loving husband, brother, father, and grandfather – passed away suddenly on November 8, 2022. Peter was born on August 16, 1947, to Barbara (Miller) Keller and C. Donald Keller in Allentown, Pennsylvania. Peter was curious about nature and the world from an early age. At six, he discovered a quartz crystal in his gravel driveway after a rainstorm that led to a lifelong love of geology and collecting. He spent weekends hunting arrowheads in the farms and fields of Lehigh County with his father. He was an active member of the Boy Scouts of America and, when he was 16, attained the highest rank of Eagle Scout and ultimately became the President of his post. At this same time, Peter was elected to the Executive Board of the Student Council at William Allen High School, from which he graduated in June 1965. After attending Penn State for a short while, Peter volunteered for the United States Air Force in 1967, during the height of the Vietnam War. An Air Force sergeant, Peter served as an intelligence analyst in Da Nang, Vietnam, in 1968-1969, and later in the Philippines and Washington, DC. After his service, Peter graduated from The George Washington University, where he majored in Geology. Peter earned his master's degree in Geology and Earth Science at the University of Texas in 1974 and his Ph.D. in Geology and Earth Science in 1977. After graduate school, Peter moved from Texas to Southern California and began his career as Curator of the Gem & Mineral Hall at the Natural History Museum of Los Angeles County. After leaving the Natural History Museum in the late 1970s, Peter joined the Gemological Institute of America as Director of Education. Peter later returned to the Natural History Museum as Associate Director for Programs. It's during this second stint at Natural History that Peter discovered his passion for creating landmark exhibits. Some of the exhibits he was most proud of included the creation of the Discovery Center for children, an exhibit of Gary Larson's Far Side comics, and working with Richard Feynman and Ralph Leighton to bring the mysterious world of Tuva to Los Angeles. Leading the Bowers Museum in April 1991, Peter assumed the post that would cement his legacy as a museum visionary and bring him immense joy: President and CEO of the Bowers Museum of Cultural Art in Santa Ana, California. Within a few years, Peter expanded the museum's physical, geographic, and cultural footprint, bringing in ambitious exhibits and overseeing the construction of new galleries. In 1994, Peter opened Kidseum, the Bowers' children's museum. In 2007, he again expanded the museum by opening the Dorothy and Donald Kennedy Wing. Over his three decades as President and CEO, the Bowers showcased over 160 exhibitions. Peter was an active member of the Explorer's Club and the Royal Geographical Society. In 2010, the Explorer's Club awarded Peter the esteemed Thomas Lowell Medal for his outstanding exploration achievements and fieldwork in New Guinea and the South Pacific. Last year, the Bowers celebrated Peter's 30th Anniversary as President of the Bowers Museum and honored him by naming its entrance the "Peter C. Keller Entrance." Peter met his wife Signe in 1996 and they instantly connected over their love of Africa, travel, and world cultures. In 1997, they were married at the Bowers Museum. Peter and Signe have traveled constantly during their 25 years of marriage. In the month before he passed, Peter was able to spend time with most of his family. In late September, Peter visited Allentown for the first time since the pandemic, revisiting his childhood home, his paper route, his high school, and the farmer's market he frequented as a child. That evening was spent with his sister, Pat, her husband, children, grandchildren, and Signe and Elizabeth. The following day, while visiting his mother's grave, Peter showed Signe and Elizabeth the family plot where he wished to be buried. No one could

imagine he would be buried there, next to his mother and father, just two months later. Peter is survived by his wife, Signe; his children, Elizabeth (husband Alex), Bret (wife Sara), Keirsten, step-daughter Meghan (husband Aric), and step-son Brian (wife Becca); his grandchildren Jack, Ava, Stella, and Aurora; his sister Patricia (husband Robert); nieces Sonya (wife Melissa, son Chase) and Tonya (husband Samuel, children Samuel, Olivia, and Isabelle); and beloved golden retriever, Matty.

Lawrence W. Leake (B.A. '59) passed away peacefully on July 19, 2023, in Tyler. Wayne was born August 18, 1936, in Kilgore, Texas, to the late Lawrence and Merle Leake. The family moved to Tyler when Wayne was a young boy. Growing up, Wayne attended Tyler schools, including Gary Elementary, Hogg Jr. High and Tyler High. After graduation, he attended the University of Texas. Wayne served as president of Kappa Sigma Fraternity and graduated with a degree in geology in 1959. He met his future wife, Emily, while at Texas, where it was "love at first sight." Wayne worked for the Texas Highway Department as a geologist for over 40 years. The Leake family attended Marvin United Methodist Church, where Wayne was a member of the Friendly Class and very active in the Marvin Menders mission group. He loved hunting and fishing with his treasured friends at the 'Duck Camp' in Reklaw and his deer lease. Wayne adored his wife, family, Labrador Retrievers, beer, bourbon, and the Texas Longhorns. Following his retirement, he built himself a shop where he spent countless hours constructing and repairing things for family and friends and just relaxing. He is survived by his daughter Laura, sister Ranna Howell, sister-in-law Ginny Shelton and husband Jim, brother-in-law Joe Sanders and wife Kay, and numerous nieces and nephews.

Ambrose Lee Lyth (M.A. '49) (aka A.L.) was born February 28, 1925, in Bellville, Texas, the third son of Ambrose Lee Lyth, Sr. and Lillie Mary Bartay Lyth. His death occurred on May 26, 2023, at Mercy Hospice House, Durango, Colorado, after a full and healthful life of 98 years. His spiritual new birth occurred in 1931 at First Baptist Church of Bellville, Texas. Ambrose's life verse was Psalm 17:15 (ESV): "As for me, I shall behold your face in righteousness; when I awake, I shall be satisfied with your likeness." Ambrose believed in the word of God and built his faith on the gospel of Jesus Christ. Ambrose graduated from Bellville High School in 1942, immediately after the start of World War II. He enlisted in the Army Air Corps in May 1943 and began training as a navigator. He was honorably discharged in September due to respiratory health issues. Following discharge, he worked at a gulf seaport loading ships that took fuel to the war theater. He enrolled at Texas A&M College and initiated his academic training in the sciences, which was completed seven years later in 1949 with bachelor's and master's degrees from Texas A&M, Washington University, and The University of Texas at Austin, respectively. In the summer and fall of 1947, he and Gladys Rinn renewed a friendship that had existed during their high school years at Bellville and were married December 27, 1947, at the Chapel on Texas State Women's College campus, Denton, Texas. They celebrated 67 years of marriage, during which time God gave them three daughters: Rebecca Louise (Smith), Mary Rinn (McPherson) and Barbara Lee (Westfall); beloved sons in law: Gale McPherson and Mike Westfall; seven grandchildren: Joshua Smith, M.D. (Kelly), Rachel McPherson Kuss (Tim), The Reverend Nathanael Smith (Emily), Sarah McPherson Badger (Jake), Joy Anne McPherson Marshall (Dr. Taylor), Jennifer Westfall Glover (Will), and Heather Westfall Schmitt (Dave); 29 great-grandchildren and other extended family. Upon graduation from The University of Texas at Austin, Ambrose began a 31-year career with Chevron Corporation, beginning as a field geologist and retiring as Chief Geologist in Denver in 1980. Following retirement from Chevron, he practiced as an independent oil and gas consultant, enabling Ambrose and Gladys to serve as volunteer missionaries for 16 years in the United States and 13 other countries. They participated in 21 separate evangelical mission endeavors outside the US. In 2006 Ambrose and Gladys moved to Durango to be close to Mary and Gale for assistance with Gladys' failing health. Through their years here, family from across the United States frequently visited this beloved family patriarch. Ambrose's and Gladys' faithfulness to God through Christ Jesus, their Savior, was exemplified in their unconditional love for their entire family. Gladys predeceased Ambrose in 2015.

Barbara June Mahler (M.A. '91, Ph.D. '97) It is with deep sorrow that we announce the death of Barbara June Mahler of Austin, Texas, who passed away on April 29, 2023, at the age of 64, leaving to mourn family and friends. She was predeceased by her husband Peter Chapman Van Metre; and her parents, Peggy Mahler and Leonard Mahler. She is survived by her friends, Paris, Montpellier, Rouen and Pete; her siblings, David L. Mahler (Lili) and Nancy M. Dixon (Mark); and also, Laura Baum (Aaron), Emily Krinsky (Jordan) and Sam Van Metre. She is also survived by four grandchildren.

Donald Evans Miser (Ph.D. '87), 68, passed away on Saturday, November 19, 2022, at Bon Secours St. Francis Medical Center in Midlothian, VA. He was born in Fort Wayne, IN, to the late Bronson Evans and Jacqueline Elizabeth (Sandlin) Miser. Donald received his doctorate in GeoChemical Science from The University of Texas at Austin. He worked as a Research Scientist for

Phillip Morris for approximately 25 years. Surviving are his wife, Vicki Miser, and children, Gregory Miser, Adam Miser and Eric Miser; brother James Miser; sister, Connie Hayden; and one grandchild.

Charles A. Payne (B.A. '85), 64, a resident of Houston, Texas, passed away on June 29, 2023, at his home from coronary artery disease. Charles was born in Houston, Texas, on September 29, 1958, to Jack Payne and Emma Lee Lentschke Payne. He was the youngest of three brothers. He was raised in the Houston area and graduated from Spring High School. He received a BA in Geology from the University of Texas and a BA in International Business from Sam Houston State University. After graduation, he enlisted in the US Army and achieved the rank of SP4. Charles received an honorable discharge. He pursued a career in financial services and helped others in several capacities. He was a mortgage broker with Countrywide Financial Services for many years. His last career position was with Fidelity Investments as a stockbroker and investment advisor. Charles was a kind person. Despite being a disabled veteran with many physical challenges, he enjoyed helping others. Charles is preceded in death by his grandparents and parents. Charles is survived by his brother, Richard Payne and wife Julie; brother, Jack Darryl Payne and wife Maria; his nephews, Robert Payne and wife Stephanie, Stephen Payne and Jason Payne; niece, Morgan Stewart and husband Emmanuel; and his great-nephew Adam Payne.

George W. Petering (M.A. '74), 82, of Anchorage, Alaska, passed away peacefully on Feb. 20, 2023, with his daughter, Jennifer, by his side. George was born on Feb. 18, 1941, to mother Frances Kirklin Petering and father Wilfred Petering in Cincinnati, Ohio. George spent most of his childhood in Lake Wales, Fla. He completed his undergraduate degree at the University of Mississippi and his graduate degree in geology from the University of Texas. Simultaneously, George served as a salvage diver in the Navy and later became the commander of the USS Cohoes during the Vietnam War. George retired as a commander from the Navy Reserves. After the Navy, George was a Shell Oil and the United States Geological Survey geologist. His work brought him to Alaska, where he worked for the USGS. In 1986, he founded Office Products Services, one of his living legacies, and continues to flourish under Yvonne Spencer's leadership. George was an avid outdoorsman, whether it be world travel or sailing around Seward, Alaska. He loved all animals, especially dogs. No dog ever went hungry or without treats when he was around. George was an active member of the Alaska Handball Association and lifelong member of the Alaska Athletic Club. Through these organizations and his work, he forged many amazing friendships. George will be remembered for his kind heart, unbreakable spirit, and quick and quirky wit. George is predeceased by his brother, John Petering. He is survived by his sister, Louise Segner; daughter, Jennifer Kearns; son-in-law, Patrick Kearns; grandson, Caleb Kearns; friend and business partner, Yvonne Spencer; and dear friend, Nikki Beckham.

William R. Pickens (B.S. '57, M.A. '59) died July 3, 2023 in Katy, Texas. Pickens received his B.S. in Geology in 1957 and his M.S. in Geology in 1959. In August of 1959, he began his career for Humble Oil Company, mapping surface geology in South Texas. He transferred into Humble's new Mineral's Department in 1967, doing uranium exploration. In 1983 Exxon closed its minerals operations, and Pickens returned to oil and gas exploration. He retired as Division Geologist in January 1992. He loved geology and always said he was lucky because he got paid to do something he loved dearly.

John D. Pigott (B.S. '74, M.A. '77) of Norman, OK, passed away on Tuesday, February 14, 2023, at 72. He was born on February 2, 1951, in Gorman, Texas. John began his education in Stephenville, Texas, and received his undergraduate and graduate degrees in Geology from The University of Texas at Austin. He further continued to pursue his Ph.D. at Northwestern University in Chicago. Before becoming a professor at The University of Oklahoma, where he was actively working until the last day of his life, John worked professionally in the oil and gas industry with the Amoco Company for a few years. While teaching and working in research at the university, he also worked as a consultant and training instructor to better professionals in the oil and gas industry for many domestic and international companies. For more than 40 years at the University of Oklahoma, John was never tired or bored in teaching or researching with his students as a professor or advisor in the Geology and Geophysics Department. John enjoyed traveling with his wife, Kulwadee Pigott when he'd been requested to teach or consult overseas. They frequently made additional travel trips to visit many places around the world. John was a devoted Catholic. He was an active and dedicated member of the St. Thomas More University Parish, the church where he loved and served as a Deacon for almost 20 years. He taught in RCIA and recently acted as a spiritual advisor for the charity formation of the parish called St. Vincent de Paul. John's faith in God was never swayed or shaken, even when facing difficult times. He strongly believed Christ had died for all humanity so we would be raised again. By that, John was always joyful in serving and encouraged others to live with Christ. John is survived by his beloved wife of 30 years, Kulwadee L. Pigott; his half-brother, Charles Smith Peek; and a few nieces and nephews. He was preceded in death by his mother, Emma Jane Lawrence, and his uncle, Dick Dowling Poe.

Peter R. Rose (B.S. '57, M.A. '59, Ph.D. '68) died of Acute Myeloid Leukemia (AML) on December 19, 2022, at 87, surrounded by his loving family. He was a fifth-generation Texan and "a man of many parts" – a loving husband, caregiver, father, grandfather, Christian, geologist, historian, country musician, scholar, teacher, entrepreneur, rancher, writer, mentor, philosopher, citizen, leader, friend. Pete was born in Austin on July 3, 1935, the second son of Mary Paterson and Llewellyn Rose. He was an Eagle Scout. He graduated from Austin High School in 1953 and the University of Texas with degrees in Geology (B.S., 1957, M.A., 1959, Ph. D. 1968). He married Judith Sue Drummond in 1956, and they had three daughters: Virginia, Cathy, and Peggy (born 1959, 1960, 1964); their marriage ended in 1978. He worked as a geologist for Shell Oil Co., State University of New York at Stony Brook, the U. S. Geological Survey, and Energy Reserves Group, Inc. Pete went on his own in 1980 as an independent consulting geologist (dba Telegraph Exploration, Inc). A second marriage to Karen Watkins ended in 1987. The third time, he finally got it right: Pete married the love of his life, Alice Haldeman Reid in 1989, two wonderful youngsters (Wally and Jennifer), a loving extended family, and many new friends. They settled in Austin, where Pete resumed his consulting practice. From 1990 through 2001 Alice and Pete traveled the world, teaching his widely-hailed corporate training courses in the newly emerging field of petroleum exploration risk analysis. This success led to the founding of Rose & Associates, LLP in 1999, which continued and expanded his expertise in teaching industry courses, supporting software, and consulting. Pete's 2001 book, Risk Analysis and Management of Petroleum Exploration Ventures, went through seven printings, was translated into Japanese, Chinese, and Russian, and is known as "The Bible" in its field. He brought into the new firm recognized professionals who were smarter than him; they finished buying him out in 2005 when he retired. Rose & Associates, LLP is known today as the leading international firm specializing in petroleum exploration and production risk analysis. Pete Rose was one of a small cadre of lucky people who "never had to work a day in their lives" —he loved being a geologist! Over 60 years, he published over 80 papers on an extremely wide variety of geotechnical topics, 13 of them after his 80th birthday! He was a compulsive reader and a polymath. Today, he is recognized as the leading authority on the geology and history of the Edwards Plateau, starting with his definitive monograph on the Edwards Limestone (1972), followed by a succession of related geological publications, and The Reckoning, the Triumph of Order on the Texas Outlaw Frontier (Texas Tech University Press, 2012), a history of how order and law came to the Texas Hill Country in the 1870s. He was a Fellow of the American Association for the Advancement of Science, the Geological Society of America, and the Geological Society of London. He frequently served as a change agent in various professional assignments and activities. Pete was an informed, outspoken, but polite critic regarding several controversial topics, such as anthropogenic climate change and critical race theory. During his retirement, Pete served his profession as the 89th President of the American Association of Petroleum Geologists (AAPG). He co-chaired a 2007 industry committee that sponsored a multidisciplinary conference in Washington, DC, to revise the definitions of SEC oil and gas reserves for new oil and gas resource plays; the SEC did so, thus encouraging private investment therein. In 2013, Pete received the Petroleum Group Medal from the Geological Society of London, the first American to receive this coveted award and 2014 AAPG's Halbouty Outstanding Leadership Award. In Austin, Pete was a member of the Austin Geological Society (President 2012/13), the English-speaking Union (President, 2011/12), the Austin Dance Club, the Geological Lunch-bunch, the Thursday morning Geriatric Golfers, Austin Christian Executives, St. David's Episcopal Church, and later, Westlake Hills Presbyterian Church, where he was a longtime member of the Senior Men's Bible Class. He served as Alice's primary caregiver after she was diagnosed with Alzheimer's Disease in early 2014. Pete was proudest of his children and stepchildren and their accomplishments and contributions. He is survived by his devoted wife of 34 years, Alice; his brother Pat Rose; daughters, Virginia Rose (Austin), Cathryn Rose (Tucson), and Peggy Rose Hanson and husband Greg (Denver); and his stepchildren, Wallace Pratt Reid and wife Kim (Houston), Jennifer Reid Hoesterey and husband Mark (Dallas), eight grandchildren; seven nephews and nieces; and eleven great nephews/nieces. Pete was predeceased by his parents, Llewellyn (1995) and Mary Paterson (2000), and his sister Sally Rose Ramsey (1991).

Thomas F. Smith (B.S. '74), 71, passed away on Thursday, March 23, at his home after a short illness. His father, T. Frank Smith Jr., and his mother, Joanne Scherer Smith, preceded him in death. He left behind his wife of 32 years, Linda K. Jordan; two sons, T. Frank Smith V (Rebecca) of Aransas Pass and Paul Smith (Jennifer) of Spring, TX; a "bonus" daughter, Leslie Jordan Willett (Michael) of Houston; sister, Toni Legrand of San Antonio, and brother David Smith (Molly) of San Antonio. He was "Papa Frank" to nine grandchildren and nine nieces and nephews. Frank was born in Brownsville but moved to Corpus Christi as a young child, where he graduated from Ray High School in 1969. In 1974, he received his Bachelor of Science degree in Geology from the University of Texas. After graduation, he joined the family business KRIS TV, where he worked until the station's sale in the late 90's. Frank was a real estate investor, developer and entrepreneur, owning and managing several businesses and properties in the Corpus

area. His many friends will remember Frank as a man of service to his community, church, and family—a man of his word with a servant spirit and a giving heart. Frank generously contributed time and money to his church and the charities he loved, serving on many boards and organizing countless fundraisers. He was a marketing guru, growing up in the family broadcasting business, where he started at the bottom at age 13, sweeping the floors and running errands for "The Old Man." He worked almost every position, including cameraman and reporter, during school and summers before graduation. He later served as Sales Executive, Design and Advertising Manager and Vice President. His father, T. Frank Smith Jr., taught him humility, respect and the ability to keep a sense of humor during a crisis. Frank had a contagious laugh, was always smiling, and kept a positive outlook on life, even after suffering health setbacks. He was a spontaneous jokester, an avid storyteller with a beautiful, booming singing voice. He was most comfortable at home in the kitchen, where he and his wife liked to cook and entertain friends and family. Frank was an Elder at First Christian Church of Portland and a supporter and Board member of many charities, including the Downtown Lions Club, the Mustangs, Sunrise Rotary Club, World Affairs Council, Palmer Drug Abuse Program, Texas State Museum of Asian Cultures, Art Museum of South Texas, Beach to Bay, Corpus Christi Executive Association and many others.

Earl B. Stanford (B.S. '51) of Byrd, Texas, passed away peacefully on December 5, 2022, after 95 years of a life well lived. He was born in Livingston, Texas, on June 28, 1927, to Isaac and Essie Lee Stanford. On December 23, 1949, Earl married the love of his life, Zelda Belle Ware. He is preceded in death by his parents and his wife of 50 years, Zelda. Earl is survived by their four boys: Mark and wife Jeanne, Brock and wife Sherri, Dan and wife Jenn, Andrew and wife Cathy; six grandchildren, three great-grandchildren; and one sister, Mary Sue Reidland. Anyone who encountered Earl was greeted with a warm hug or firm handshake, humble kindness, a witty sense of humor, and always an open heart. Earl served in the Navy immediately following high school graduation, experienced a Japan tour, and then used his hard-earned GI Bill grant money by attending The University of Texas at Austin. He became an accomplished exploration geophysicist and worked for Exxon for 30+ years. Earl had a unique talent for interpreting seismic data with incredible accuracy in the pursuit of unveiling natural gas and oil. He loved it, and Exxon noticed. Together with their children, Earl and Zelda lived in and traveled to many beautiful places all over the world during Earl's time with Exxon. They experienced different parts of Asia, Africa, North America, Europe, and Australia. Earl lived grand and humble all at the same time. He had faith in God, his wife, the greater good of humanity, and simple everyday joys like no other. When it was retirement time in 1983, Earl made good on his promise to Zelda. They lived the rest of their lives on their farm in her hometown of Byrd, Texas, and were dedicated members of the Church of Christ in Bardwell. Earl will be deeply missed by all who knew and loved him.

James D. Webb (B.S. '52) passed away on Friday, the 23rd of June, 2023, in Houston, Texas. He was 92 years of age. He was born to Edith Lorena Miller Webb and Arthur Darrell Webb on the 27th of April 1931 in Big Spring, Texas. Jim was raised by Edith and Darrell Webb, who eloped when they were too young to have acquired many skills that come with life's lessons. Even so, they built a family together and saw both sons graduate from college. Jim described his parents as God-fearing and hard-working people who did their best raising boys during the Great Depression. He was proud of his family. After arriving at The University of Texas at Austin in 1948, Jim joined the Alpha Tau Omega fraternity, where he felt a sense of belonging for the first time. He admired his ATO brothers, many of whom had fought overseas in World War II. Jim graduated with a degree in Geology in 1952 and began a 70-year career in the oil and gas industry. He loved the science of geology; he took pride in providing for his family. He felt joy in the camaraderie with the businessmen at the Petroleum Club, with the roughnecks at the rig, who waited while Jim looked at core samples under his microscope, and with the other hopeful explorers in the quiet of the land library, reading logs, looking for the next big lick. Jim met Irene Patricia Hogan from Breckenridge, Texas, on a blind date in 1951, and they fell into a true and beautiful love with one another that would last until her sudden and early death in 1975. Pat's death left Jim a 43-year-old widower with five children, ages 23 to 7. In the following chapters, he started his own exploration company, moved to Denver, Houston, Arkansas, and back to Midland again. He remarried; he loved his wives. He was a good friend. He loved, respected, and often bragged about his children. He was a thinker. Jim was interested in the largest questions in life: Why are we here? What is the universe expanding into? He was intellectually curious and loved reading and discussing the philosophies of Albert Einstein, Carl Sagan, and Bertrand Russell. He is preceded in death by his wives, Irene Patricia Hogan Webb and Norma Jean Helm Webb, and by his son, James David Webb, Jr. He is survived by his children Janet Webb, John Webb (Sharon Webb), Jeff Webb (Shirley Webb), and Jill Webb (Susan Webb), as well as 14 grandchildren and 27 great-grandchildren.

Friends

Janice Hood Barrow, age 94, passed away on Friday, the 16th of December 2022, in Houston. She was born on the 21st of October 1928, in Portland, Oregon, to Lucile & Wilbur Hood. Humor and laughter were always present around Jan. She first met Thomas D. Barrow at Stanford University in 1948 on a blind date as part of an elaborate practical joke to be played on a friend of Tom's. The joke was soon forgotten, but Tom proposed on their quickly scheduled second date. "Certainly not!" she replied, but the couple were married in September of 1950 after Jan graduated with her degree in political science. Soon after that, they began a nomadic life together that lasted 61 years and took them to four California cities, New Orleans, two cities in Connecticut, and four times to Houston. Jan would need her sense of humor to survive all the moves and the four children she bore and raised along the way. Christian faith was the bedrock of Jan and Tom's life together. Jan was raised in Portland in a devout Baptist family. After marrying, Jan and Tom embraced the Episcopal Church as the spiritual home in which to nurture their faith and raise their children. Jan was never satisfied to follow when leadership was needed, and she was active in every church community the couple joined. Between raising the children and managing the home, Jan actively volunteered in every community where the family lived. Early in her married life, Jan joined the Junior League of Pasadena. Wherever the family moved, Jan joined the Junior League and was particularly active in New Orleans and Houston, having a particular interest in the League's Well Baby Clinic. Her active community service culminated in co-chairing the Houston Job Fair in the Astrodome. Jan's commitment to service extended to the medical arts as well. She was a dedicated supporter of Houston Methodist Hospital and a founding Director of the hospital's Center for Performing Arts Medicine. She served as a Director of the Houston Speech and Hearing Clinic and as a Director of AWARE, an organization dedicated to Alzheimer's disease support and research. Jan's modest appraisal of her talents aside, music, mainly classical music was her passion. First exposed to world-class orchestral and operatic music at Stanford and in San Francisco, Jan's love for fine music grew greater throughout her life. It led to years of volunteer service with orchestras across the country. In New Orleans, she helped to organize the Junior Committee of the New Orleans Philharmonic Orchestra and served as its second President. She then became a Director of the New Orleans Philharmonic Orchestra. In Houston, Jan and Tom sponsored dozens of aspiring and established musicians at the Houston Grand Opera Studio and the Houston Symphony. Connecting with these artists was one of her greatest joys; she maintained those friendships for life. To help promote music education and love for classical music in future generations, Jan served as a Trustee of the Shepherd School of Music at Rice University. Jan's active support of the fine arts was capped by a two-year term as President of the Houston Symphony Society, to which she was later honored as a Lifetime Trustee. If music was her passion, travel and adventure were Jan's joys. Whether for work or pleasure, Jan and Tom covered the globe together. At home was a map of the world, dotted with stickpins to show every destination. Each pin could stimulate an evening of stories and happy memories of adventures with family and friends. She also reveled in the travel adventures she inspired her children and grandchildren to pursue. Jan was preceded in death by her parents, Lucile Loyd Hood and Wilbur Kenneth Hood, and her husband, Thomas Davies Barrow. She is survived by her sister, Barbara Conner of Portland, Oregon; sons, Ted Barrow and wife Clare of San Diego, California, and Ken Barrow and wife Donna of Denver, Colorado; daughters, Barbara McCelvey and husband Pat and Elizabeth Brueggeman and husband Mark, both of Houston; beloved niece, Gayle Aman and husband Bob; grandchildren, Jane Barrow and husband Steve, Tom Barrow and wife Rebecca, Sarah Barrow and husband Eric Smith, Lee Barrow and wife Betsy, James McCelvey and wife Crystal, Daniel McCelvey and wife Laurie, Eric Brueggeman, Peter Brueggeman, and Kevin Brueggeman and wife Adair; grand-niece, Kathleen Moffitt and husband Chad; and nine great-grandchildren.

Charles W. Duncan lived a life that exemplified the best of his generation through service to his country, state, city, and family. With Anne, his wife of 65 years, by his side and fueled by his strong sense of duty and loyalty, he lived a life full of integrity, business success, good works, and adventure alongside beloved friends and family. Charles was born on the 9th of September 1926, in Houston, Texas, to Charles William Duncan and Mary Lillian House, and grew up on Avalon Street with his younger brother, John. He attended public schools in Houston and graduated from Sewanee Military Academy in 1943. He returned to Houston and enrolled at the Rice Institute (now Rice University). In 1944, while attending Rice, and on his 18th birthday, he and his best friend, Jack Trotter, joined the Army Air Forces as Aviation Cadets, and as World War II was coming to an end, Charles was honorably discharged after nine months of service. Upon graduating from Rice in 1947 with a degree in chemical engineering, he worked briefly as a roustabout for Humble Oil and Refining. Encouraged by his father to join the family coffee business, he studied business at The University of Texas at Austin. Charles began work at the Duncan Coffee Company in 1949, ultimately running the business until it was sold in 1957 upon the death of his uncle, Herschel Mills Duncan. He remained at the company as President under the new owners. Still, he and his brother partnered with many childhood friends, including Ed Randall, to

repurchase the company in 1959. Charles and a management team that included Pierre Roberts rapidly expanded the business through acquisitions, extending Duncan Coffee's range from Texas to most of the central part of the country. In 1964, The Coca-Cola Company acquired Duncan Coffee, which merged the coffee business with their Minute Maid Company to form the Coca-Cola Foods Division. Charles led Coca Cola Foods for three years before he and his wife, Anne, moved their young family to London to establish Coca-Cola Europe, a territory extending from Iceland to India, including Africa and the Middle East. He and Anne embraced their new life of overseas living and travel as he managed the company's far-flung operations. After working under the mentorship of Coke Chairman Robert Woodruff, Charles became the President of Coca-Cola. Expanding on Coca-Cola's pioneering lifestyle advertising, Charles was especially proud of his participation in developing the swoop logo and the "I'd Like to Buy the World a Coke" advertisements. In 1974, he left his active role at Coca-Cola to return to Houston, but he retained a board seat and kept an active interest in the company for the rest of his life. In 1976, President-Elect Jimmy Carter asked Charles to become Deputy Secretary of Defense. He was tasked with managing the day-to-day operations of the Department of Defense at the Pentagon in the new administration. He often said his two and a half years at the Pentagon were the most rewarding time in his career. It was here that he met Colin Powell, who was named his military aide. The two traveled together to Iran in December 1978 for the last official meeting between the Shah of Iran and the U.S. government before the Iranian revolution. When Powell was promoted to Brigadier General the following year, Charles pinned the star on Powell's epaulet. In 1979, as the energy crisis took hold, President Carter appointed Charles to his Cabinet as the Secretary of Energy, citing his exceptional management and leadership skills as his key qualifications to guide the department successfully. He worked diligently with other countries' governments and Middle East producers to help stem the supply and demand imbalance. He also oversaw the first meaningful efforts by the U.S. to develop alternative energy sources. Upon returning to Houston, Charles rejoined his brother and son in the investment business. Charles joined several corporate boards, including Texas Commerce Bank (now JPMorgan Chase), American Express, and United Technologies, where he served for many years as lead director. Later in life, he managed the affairs of Duncan Interests and Duncan Capital Management with the help of an able team. led by Michael Hay, Laura Meinhardt, Pete Faust, and Betty Bruffy. Charles was active in city affairs, participating in leadership at the Houston Chamber of Commerce and the Houston Economic Development Council, helping to merge the two entities to become today's Greater Houston Partnership, where he served as the first Chairman and remained active for many years. Charles' primary civic interest was always education, expressed through his life-long service to his alma mater, Rice University. George R. Brown, the Chairman of Rice's board at the time, encouraged him to join the Board of Governors in 1965. Upon his return to Houston from Washington D.C., he became a Trustee and was elected the university's Chairman in 1982. During his long association with Rice, he served alongside many of the university's Presidents, including Norman Hackerman, George Rupp, Malcolm Gillis, and David Leebron. Charles' interest in education extended beyond Rice to public education in Texas, and Governor Mark White appointed him to the Select Committee on Public Education and to the State Board of Education. He also founded the Texas Business and Education Coalition in 1989. Charles and Anne have been generous to many other Houston organizations, most notably the Museum of Fine Arts, Houston, and Houston Methodist Hospital. Valuing leisure as much as work, Charles enjoyed fishing in the Florida Keys, skiing in the Rockies, shooting in South Texas, camping in Africa, and playing tennis everywhere. Over 50 years ago, he and Anne bought Buffalo Bill's TE Ranch in Cody, Wyoming. With the help of managers Karen and Curt Bales, "the TE" has been the family's favorite way to entertain friends while enjoying ranching traditions. Charles and his beloved wife, Anne Smith, were married in Houston in 1957. Their son, Charles III, was born in 1959, and their daughter, Mary Anne, in 1961. Charles was blessed to be close to his brother, John, all his life, and throughout the years, their families shared many vacations and time at Honey Creek Ranch. He was a devoted father and grandfather and proudly attended horse shows, softball tournaments, lacrosse games, and graduations. His grandson, Paul, graduated from Rice University in 2017, and Charles was on stage at age 91 to hand Paul his diploma - 70 years after receiving his own. Charles was preceded in death by an infant son, his parents, his sister Mary Elise Duncan, and his brother, John House Duncan. His sisters-in-law, Jeaneane Duncan, Barbara Alexander, and Loeene Nelson, and his brother-in-law Donald Smith also predecease him. He is survived by his wife Anne; his son Charles William Duncan, III and wife, Leslie Rowan Duncan; his daughter Mary Anne Duncan Dingus, and husband William Frederick Dingus. His five beloved grandchildren also survive him. Charles is also survived by his nephew, John H. Duncan, Jr.; his niece, Nena Duncan Marsh; his sisters-in-law, Brenda Duncan, Bette Washburn, and Sandra Turner; and many other relatives.

David N. Grimes of Midland, Texas passed away at home on Good Friday, April 7, 2023. He was born August 24, 1928, the first of four children born on Pearl Street in Paola, Kansas to Dr. Floyd J. Grimes, Sr. and Lillian Oyster Grimes. David graduated from Paola High School in 1946. He made life-long friends and later shared

humorous tales with remarkable characters and big adventures from his Paola upbringing. To his chagrin, President Truman declined David's written request to assist with atomic bomb testing in the South Pacific evidently preferring nuclear scientists over 16-year-old David. Undeterred, David charted a path filled with curiosity and creativity, romance, and broad interests that he pursued for the rest of his life. David attended University of Kansas, was president of Phi Kappa Psi fraternity, where he roomed with hooded hawks and raptors captured in the wilds for the University biology department. He literally walked across the State of Illinois and parts of Kansas and Missouri working as a pipeliner for Panhandle Eastern during summers and school breaks. David graduated in '52 with a BS in Geology, joined the Navy, graduated from OCS in Newport, RI, was commissioned Lieutenant JG, and was stationed in San Diego along with his brother, Floyd J. David served aboard ship for much of his Navy career, sailing across the Pacific many times. Now Lieutenant in the Navy Reserve, David moved to Midland with Union Oil of California as a petroleum geologist, and here, he met the love of his life, his bride-to-be, Sarah Lew Link. They married in the chapel at First Presbyterian Church on June 7, 1957, and for the next 63 years they were inseparable, making Midland their home except for a short tour in Denver. Together they raised their children, Amy, Link and Ann. He loved to travel with Sarah Lew and the kids. He was always packing and unpacking the station wagon for trips that would include stops along roadside cuts to study rock formations, take pictures, and consult his rather expansive traveling geology library. The sea was a passion, and seaside trips were a favorite, especially around his navy home, La Jolla. He delighted in being a geoscientist. His shop was loaded with sample bags, cores, and rocks. He enjoyed the process of prospecting and was pleased when efforts paid off, yet was accepting of the "dry hole" when it occurred, as it inevitably does. West Texas Geological Society honored David with its Petroleum Pioneer Award, and American Association of Petroleum Geologists honored him for a remarkable 70 continuous years of membership and service. David never retired, following the energy industry's latest exploration and development news until his death. David was a member and elder of First Presbyterian Church Midland. He served on MISD School Board, was a long-time board member and chair of Midland County Appraisal District, President of The Texas Association of Appraisal Districts, and had membership in Rotary Club of Midland, Society of Independent Professional Earth Scientists, Midland Exchange Club, Sons of the American Revolution, and supported The Congressional Cemetery in Washington, D.C. David rode his bicycle to work downtown almost every day, a practice he maintained until he was 88. He studied astronomy and was a supporter of the planetarium. He sketched and painted, was an amateur (HAM) radio operator KA5ZKA, sailed a Flying Scot, knew Morse code, and was proficient in sign language - signing love and wishes in his final days. He was kind and thoughtful and made many friends. He loved his children, always listened, and had time to talk when they called. He and Sarah Lew attended their every game, match, performance, graduation and big event. They loved dining with family, often lingering at table until closing. David is predeceased by his "dearheart" Sarah Lew, his parents Floyd J. and Lillian Grimes, his brother Dr. Floyd J. Grimes, II, and his sister Francie Alt and husband Mike. David is survived by daughter Amy Grimes Ehrlich and husband Bob of Austin; by son David Link Grimes and wife Missy of Midland; and by daughter Sarah Ann Grimes and husband Jay Old of Austin; and nine grandchildren. Survivors include sister Lillie Larsen, husband Max of Lincoln, Nebraska, sister-in-law Mary Ann Grimes of Paola, Kansas, and numerous nieces and nephews.

Karl Frederick Hagemeier, 69, passed away on May 12, 2023, in his home in Kerrville, TX. Karl was born on November 1, 1953, to Karl F. Hagemeier Jr. and Dottie Tillis Hagemeier in New Orleans, LA. Growing up in New Orleans gave him two of his favorite things: a love for music and an education from Jesuit New Orleans High School, where he was Class of 1972. Until the end, Karl was proud of his time at Jesuit and the influence of the Jesuit priests and philosophy, which he credits for changing his life. After high school, Karl moved to Austin, TX, where he met some of his dearest friends, made memories playing Rugby, and enjoyed the good times (which turned into stories we heard numerous times). Karl received his undergraduate degree in Liberal Arts with a Major in English from The University of Texas at Austin in 1976. He then pursued a medical degree at Baylor College of Medicine, graduating with Honors in 1982. Karl married the love of his life, Jo Ann Vogt, on April 4, 1981, and after a general surgery residency at Scott & White in Temple, TX, he and his family moved to Kerrville, TX, where he practiced as a general surgeon for 27 years at Peterson Regional Medical Center. Karl's dedication to helping others was seen in his love and care for his patients. His heart for helping the underprivileged led to his commitment of time and talent to the Raphael Clinic, where he was one of the founders. Karl was a member of Phi Beta Kappa and a two-time winner at the Peterson Regional Medical Center Academy Awards, taking home the Best Sense of Humor award in 2007 and Friendliest in 2011. Karl loved watching his three daughters play sports, supporting his wife in all her endeavors, playing guitar, reading, and cheering on the Texas Longhorns. Karl is survived by his wife, Jo Ann; his three daughters, Kelly, Mattie (Jeff), and Elsa; his two grandchildren, James and Lena, who lovingly referred to him as "Doc"; his sister Jeannie (John); their children

Emily, Charlotte and Graham, and his beloved Old English Sheepdog, Harley. Karl is also lovingly remembered by Jo Ann's siblings and their children.

Leonard E. Huber, Marine fighter pilot, rodeo rider, banker, tennis player, beloved husband, father, brother, and friend, flew his last flight to his maker on Oct. 7, 2022, at 91. He lived a full and adventurous life, leaving in his wake, the world a better place. He was a gentleman and a gentle man and a proven leader. Friends saw him as a role model in many ways, especially on how to age with grace and vitality. Generosity was important to him, and throughout his life he shared his life's blessings with family and many friends, never wanting anyone to be in need. After graduating from The University of Texas at Austin with a degree in Business Administration, Leonard joined the U.S. Marines as a fighter pilot and flight instructor, achieving the rank of Major. Following the Marines, he had a long and successful career in the banking industry through executive positions at First National Bank of Dallas, First International Banc Shares, the InterFirst Banks in San Antonio, the Federal Home Loan Bank, American Federal Bank, and Franklin Federal Bankcorp. In the 1990s Leonard met and married his wife, Karen. They built their home in the Hill Country west of Austin, which they enjoyed with their German Shorthaired Pointers, Ami, Jag, and Cookie. They traveled the world together with family and friends, visiting Africa, Europe, Scandinavia, Russia, South America, the Caribbean, and Hawaii. Leonard was also an avid tennis player and enjoyed playing at World of Tennis in Lakeway and Wednesday lunches with the tennis gang for the last 25 years. Awaiting on this earth to join him in the future are his wife, Karen; his son Wayne and wife Linda; daughter Cindy Wells and husband James; grandsons Brian Huber, Aaron Wells and wife Caren, Alex Wells, Austin Wells and wife Abby; great-grandson Nicolas Wells; an extended family of siblings, cousins, nieces and nephews, and many friends. He was preceded in death by his mother, Lorine Orem, and father, Lovell Huber, and his beloved sister, Peggy Hill.

Orion Knox, a pillar of Texas and Mexico speleology, has passed away. Orion Knox was one of the discoverers of Natural Bridge Caverns in 1960 and one of the first cavers to go to Huantla, Oaxaca, Mexico. He started caving in 1957 while still in high school and, at age 78, was on a trip to the Dome Pit in Natural Bridge Caverns in 2019. He met his wife, Jan, through the local grotto at The University of Texas at Austin. Together they became a surveying team and worked on Harrison's Cave in Barbados, Kartchner Caverns in Arizona, Natural Bridge Caverns TX, and numerous others. When traveling they would include a stop at any local caves that were open. Upon graduation, he went to work for Texas Parks and Wildlife. Starting as a park planner and later becoming the head of the Historic Sites branch in Texas Parks. He worked on the first restoration of the Battleship Texas. He said crawling in the battleship was similar to caving. He will always be remembered as friendly, smiling and a good storyteller. He will be greatly missed.

Terry B. Newman was born on May 5, 1958, and was taken too soon on June 5, 2023. She will be remembered as a woman who embodied love, compassion, and unwavering commitment to her loved ones. Her adventurous spirit, nurturing nature, and meaningful connections left a lasting imprint. May her remarkable legacy inspire us to cherish relationships, embrace our free-spirited nature, and spread love and kindness in the world, just as she did throughout her extraordinary life.

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All personal and work information submitted is confidential and will not be shared outside of The University of Texas at Austin. All fields are optional but we appreciate your effort to help us keep your information accurate and current. All alumni, research scientists, faculty and staff affiliated with JSG and its research units are encouraged to submit.

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