THE UNIVERSITY OF TEXAS AT AUSTIN · JACKSON SCHOOL OF GEOSCIENCES · 2020 NEWSLETTER

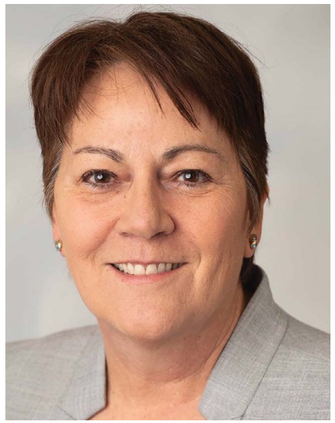
2020 Newsletter

Understanding Fractures, Getting To Know Dean Mora, Diversity in the Geosciences, and Learning During COVID-19

TEXAS Geosciences
The University of Texas at Austin
Jackson School of Geosciences

NOW MORE THAN EVER, YOUR GIFTS MAKE A TREMENDOUS DIFFERENCE

Dear Alumni and Friends



Welcome to the 2020 Jackson School of Geosciences *Newsletter*, the 71st geoscience newsletter at The University of Texas at Austin and my first as dean. I have always looked forward to the arrival of the annual newsletter from my own alma maters. Newsletters tie alumni and school communities together. Even as we read about new Jackson School research, faculty and achievements, we are reminded of our own time in school, times of intellectual growth and the start of lifelong friendships. After such a challenging year, it is heartening to hear of the steady success of the Jackson School. Our shared pride feels good.

Spring ushered in the coronavirus pandemic, and all of us continue to be affected by its constraints and costs, both physical and emotional. The Jackson School has not been immune. You will see examples of the impact of COVID-19 on the Jackson School throughout the *Newsletter*, but you will also see that we are still conducting the cutting-edge, societally important research that we are known for, and we are educating and preparing the next generation of geoscientists to tackle the challenges ahead.

I am very proud of our students, faculty, research scientists and staff for enabling the success of remote and socially distanced learning and research, and I think you will be too. See the feature on page 54 on the many efforts that brought our research and teaching back to life after the initial shock of the COVID-19 closure.

Like past issues, this *Newsletter* includes updates on cutting-edge science at the Jackson School. One story on page 26 showcases the Bureau of Economic Geology's FRAC research group and their unique approach to studying rock fractures—a topic impacting energy and water resources, and subsurface storage. The spring also brought renewed efforts across the Jackson School to address the lack of diversity in our school and the geosciences, in general. Learn more on page 40 about this stubborn, longstanding challenge and what the Jackson School is doing to attract and support geoscientists from diverse backgrounds.

In the profiles section, we welcome new members of the Jackson School, such as the Bureau of Economic Geology's new Associate Director Kenneth Wisian, and honor those who have done so much for us, such as former Department of Geological Sciences Chair Ron Steel, who became a professor emeritus this year. You can also learn a little more about my life, research and plans for the Jackson School.

And, sadly, we said goodbye this year to longtime friends and colleagues: Dennis Trombatore, the head librarian for the Walter Geology Library; Stephen Ruppel, senior research scientist at the Bureau of Economic Geology; Robert Tatham, professor and Shell Centennial Chair in Geophysics; and, Bill White, a longtime researcher at the Bureau of Economic Geology. Read more about these special colleagues in the memorial section. I know all were beloved and will be greatly missed by the Jackson School family.

I know that many of us are ready to see 2020 just go away. But the school remains strong, and we are grateful for your steadfast support and interest. I hope the end of the year brings you a few special treats: time with family, a chance to celebrate the season, to eat (or re-gift) that fruitcake, and a quiet moment and cozy chair for enjoying the *Newsletter!*

Blessings and good health to all,

Claudia Mora, Dean

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Fractures are ubiquitous and vitally important to nearly everything that happens in the subsurface, yet they are not well understood. Researchers are working to change that by looking at the crystals that form inside fractures.

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With their historic 2022 coring mission looming, scientists at the Jackson School of Geosciences are honing their tools and skills for pulling samples of methane hydrate from beneath the seafloor of the Gulf of Mexico. The volatile, energy-rich substance could be a fuel of the future.

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The geosciences are among the least diverse STEM fields. At every level, the Jackson School of Geosciences is working to change that.

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A quarter-mile rock core is shedding light—and raising questions—on the turbulent events of the Late Triassic.

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76 **Meet the New Dean**
Claudia Mora has had a long, varied career in geosciences—serving as a division leader at Los Alamos National Laboratory, and head of the geology department at the University of Tennessee. In February 2020, she took the helm of the Jackson School of Geosciences as dean.

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From quarantining to expeditionary style camping, the Jackson School of Geosciences revamped its capstone summer field camp, GEO 660, to offer the foundational experience to graduating seniors despite the obstacles posed by the pandemic.

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Retired Air Force Major General Ken Wisian joins the Bureau of Economic Geology as the associate director of the Environmental Division.

14 **Iron Snow at Earth's Core**
The Earth's inner core is hot, under immense pressure and snow-capped, according to new research that could help scientists better understand forces that affect the entire planet.

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The American Geosciences Institute has honored Professor Sharon Mosher with the 2020 Marcus Milling Legendary Geoscientist Medal.

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ON THE COVER: TIGHT-GAS SANDSTONE FROM VIENNA BASIN, AUSTRIA. PICTURE IS A COMBINATION IMAGE. THE BACKGROUND IS A SECONDARY ELECTRON IMAGE OVERLAID WITH COLOR SEM-CL TO DISTINGUISH DETRITAL GRAINS FROM DARK BLUE QUARTZ CEMENT. CREDIT: SARA ELLIOTT.

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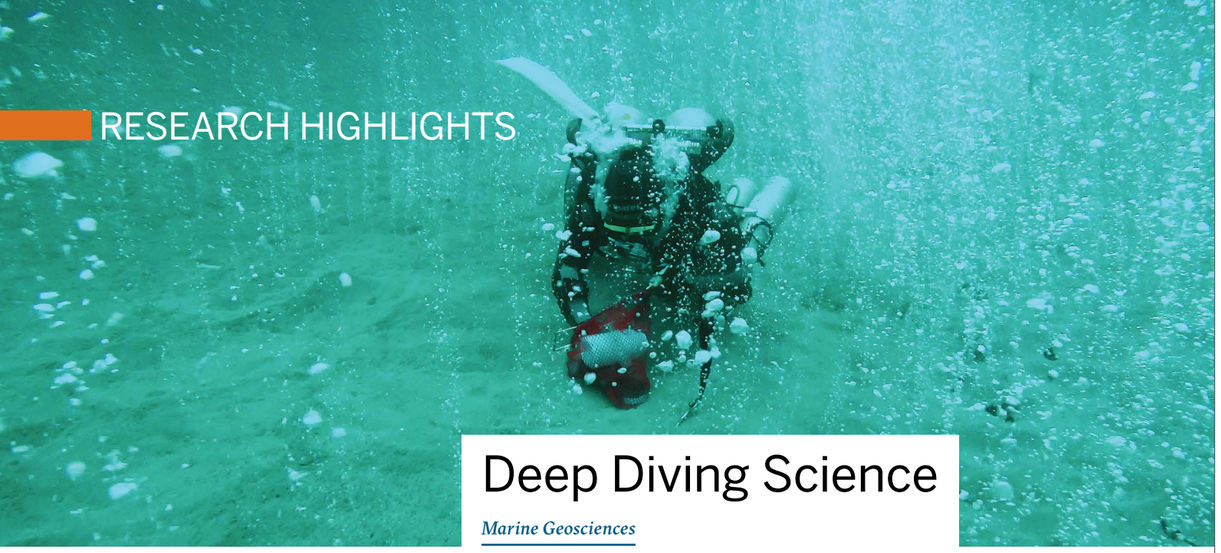


Deep Diving Science

Marine Geosciences

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 Geological 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*

ABOVE: COLLECTING GAS SAMPLES AT "SODA SPRINGS" IN THE PHILIPPINES.

Diving 200 feet under the ocean surface to conduct scientific research can lead to some interesting places. For Jackson School of Geosciences Professor Bayani Cardenas, it placed him in the middle of a champagne-like environment of bubbling carbon dioxide, with off-the-chart readings of the greenhouse gas.

Cardenas discovered the region — which he calls "Soda Springs" — while studying how groundwater from an island in the Philippines could affect the ocean environment of the Verde Island Passage. The passage is one of the most diverse marine ecosystems in the world and is home to thriving coral reefs.

The amazing bubbling location, which Cardenas captured on video, is not a climate change nightmare. It is linked to a nearby volcano that vents out the gases through cracks in the ocean floor and has probably been doing so for decades or even millennia. However, Cardenas said that the high CO_2 levels could make Soda Springs an ideal spot for studying how coral reefs may cope with climate change.

"These high CO_2 environments that are actually close to thriving reefs, how does it work?" said Cardenas. "Life is still thriving there, but perhaps not the kind that we are used to. They need to be studied."

Cardenas and co-authors from institutions in the Philippines, the Netherlands and UT described Soda Springs along with multiple scientific findings about groundwater in a paper published Jan. 16, 2020, in the journal *Geophysical Research Letters*.

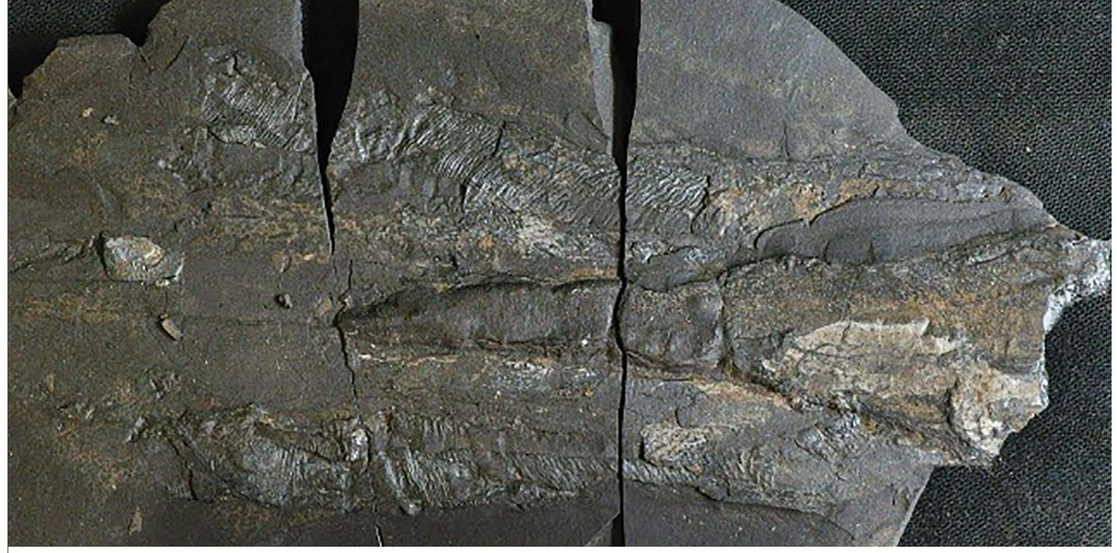
The scientists measured CO_2 concentrations as high as 95,000 parts per million (ppm), more than 200 times the concentration of CO_2 found in the atmosphere. The readings range from 60,000 to 95,000 and are potentially the highest ever recorded in nature. The CO_2 levels fall quickly away from the seeps as the gas is diluted in the ocean, but the gas still creates an elevated CO_2 environment along the rest of the coastline of the Calumpan Peninsula, with levels in the 400 to 600 ppm range.

Cardenas is a hydrologist and not an expert on reef systems. He discovered Soda Springs while researching whether groundwater from the nearby land could be discharging into the submarine ocean environment, which is a phenomenon that is generally ignored by scientists looking at the water cycle, Cardenas said.

The team tracked groundwater by testing for radon 222, a naturally occurring radioactive isotope that is found in local groundwater but not in open ocean water. Along with the CO_2 bubbles, the team found hotspots in the seafloor where groundwater was being discharged into the ocean. This is significant, said Cardenas, because the connection between the groundwater and ocean means that there is a pathway for pollutants from the island to reach the reef system.

This is particularly important for a place such as the Philippines, he said, where coastal development is booming largely because of ecotourism driven by the nearby reefs, but the communities almost always depend on septic tanks instead of modern sewage systems.

PHOTO: BAYANI CARDENAS.



Exceptional Fossils Need Puff of Air

Planetary Sciences & Geobiology

Some of the world's most exquisite fossil beds were formed millions of years ago during periods when the Earth's oceans were largely without oxygen.

That association has led paleontologists to believe that the world's best-preserved fossil collections come from choked oceans. But research led by the Jackson School of Geosciences has found that while low-oxygen environments set the stage, it takes a breath of air to catalyze the fossilization process.

"The traditional thinking about these exceptionally preserved fossil sites is wrong," said lead author Drew Muscente. "It is not the absence of oxygen that allows them to be preserved and fossilized. It is the presence of oxygen under the right circumstances."

The research was published on Nov. 5, 2019, in the journal *PALAIOS*.

Muscente, an assistant professor at Cornell College in Mount Vernon, Iowa, conducted the research during a postdoctoral research fellowship at the Jackson School. Co-authors include Associate Professor Rowan Martindale and undergraduate students Brooke Bogan and Abby Creighton, in the Jackson School's Department of Geological Sciences.

The best-preserved fossil deposits are called "Konservat-lagerstätten." They are rare and scientifically valuable because they preserve soft tissues along with hard ones — which in turn, preserves a greater variety of life from ancient ecosystems. The research examined the fossilization history of an exceptional fossil site located at Ya Ha Tinda Ranch in Canada's Banff National Park. The site, which Martindale described in a 2017 paper, is known for its cache of delicate marine specimens, such as lobsters and vampire squids with their ink sacks still intact preserved, in slabs of black shale from the Early Jurassic.

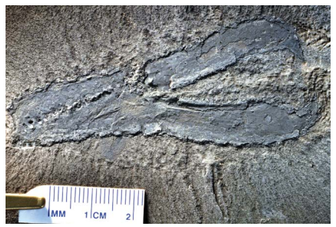
During the time of fossilization, about 183 million years ago, high global temperatures sapped oxygen from the oceans. To determine whether the fossils did indeed form in an oxygen-deprived environment, the team analyzed minerals in the fossils. Because different minerals form under different chemical conditions, the research could determine whether oxygen was present.

The analysis involved using a scanning electron microscope to detect the mineral makeup.

The workup revealed that the vast majority of the fossils are made of apatite, a phosphate-based mineral that needs oxygen to form. However, the research also found that the climatic conditions of a low-oxygen environment helped set the stage for fossilization once oxygen became available.

That's because periods of low ocean oxygen are linked to high global temperatures that raise sea levels and erode rock, which is a rich source of phosphate to help form fossils. If the low oxygen environment persisted, this sediment would simply release its phosphate into the ocean. But with oxygen around, the phosphate stays in the sediment, where it could start the fossilization process.

ABOVE: A FOSSILIZED MANTLE OF A VAMPYROPOD, A RELATIVE OF THE VAMPIRE SQUID.
BELOW: A FOSSILIZED LOBSTER CLAW THAT MAY BELONG TO A NEW SPECIES.



PHOTOS: ROWAN MARTINDALE.

A CORE SAMPLE CONTAINING METHANE HYDRATE (WHITE).

Solving the Methane Hydrate Gas Bubble Mystery

Energy Geosciences

New research has explained an important mystery about natural gas hydrate formations and, in doing so, advanced scientists' understanding of how gas hydrates could contribute to climate change and energy security.

The research used a computer model of gas bubbles flowing through hydrate deposits, a common phenomenon in nature that, according to existing models, should not be possible. The new model helps explain how some deposits grow into massive natural gas hydrate reservoirs such as those found beneath the Gulf of Mexico. A paper describing the research was published Jan. 15, 2020, in the journal *Geophysical Research Letters*.

Gas hydrates are an icy substance in which gas molecules, typically methane, become trapped in water-ice cages under high pressure and low temperature. They are found widely in nature, house a substantial fraction of the world's organic carbon and could become a future energy resource. However, many questions remain about how hydrate deposits form and evolve.

One such question was raised by observations in the field that spotted methane flowing freely as a gas through hydrate deposits in the subsurface. What puzzled scientists is that under conditions where hydrates occur, methane should exist only as a hydrate, not as a free gas. To solve the mystery of the free-flowing gas, a team of researchers led by Dylan Meyer, a graduate student at the Jackson School of Geosciences, re-created in the lab what they saw in the field.

Using this data, they hypothesized that as hydrate forms in a deposit, it also acts as a barrier between gas and water, restricting the speed at which new hydrate forms and allowing much of the gas to bubble through the deposit. They developed this idea into a computer model and found that the model matched experimental results. When scaled up, they also matched evidence from field studies, making it the first model of the phenomena to successfully do both. Crucially, the model suggests that gas flowing through the subsurface can accumulate into large, concentrated hydrate reservoirs, which could be suitable targets for future energy sources.

"The model convincingly reproduces a range of independent experimental results, which strongly support the fundamental concepts behind it," said Meyer. "We believe this model will be an essential tool for future studies investigating the evolution of large, highly concentrated hydrate reservoirs that experience relatively rapid gas flow through porous media."

Climate Resilient Mollusks

Climate & Environment

About 55 million years ago, a rapidly warming climate decimated marine communities around the world. But it was a different story for snails, clams and other mollusks living in the shallow waters along what is now the Gulf Coast of the United States. They were able to survive.

The findings, published Feb. 7, 2020, in the journal *Scientific Reports,* suggest that mollusks in the region might also adapt to the climate change of today.

"Mollusks are sort of unique in this aspect, as they are better adapted to cope with high temperatures," said lead author William Foster, an assistant professor at the University College Dublin and former postdoctoral researcher at the Jackson School of Geosciences.

The backbone of the research is from the personal collection of amateur Austin paleontologist Christopher Garvie. He has collected Gulf Coast mollusk fossils during the past 30 years and estimates his collection includes more than a quarter million specimens from sites ranging from Texas to Florida on the Gulf Coast and Florida to New Jersey on the Atlantic Coast.

During the time the research focuses on, the Earth was in a warmer state than it is today, with no large ice sheets covering the poles. Even in this "hot house" state, the period contained multiple temperature spikes that warmed the planet even more. One of these spikes—the Paleocene-Eocene Thermal Maximum (PETM)—occurred about 55 million years ago and is frequently compared with the human-driven climate change happening today. During the PETM, atmospheric carbon dioxide rose rapidly, which in turn caused average global temperatures to rise 9 to 14 degrees Fahrenheit.

Although the PETM led to a decline in coral reef communities and the mass extinction of seafloor-dwelling plankton called foraminifera, the Gulf Coast mollusks survived.

"It does highlight that even in events that we think are devastating, there's still a bit of hope from these resilient communities," said co-author Rowan Martindale, an associate professor in the Department of Geological Sciences.

MIDDLE EOCENE GASTROPOD COLLECTED IN TEXAS.

ECLECTIC ROCKS: IODP JRSO. MOLLUSKS: CHRISTOPHER GARVIE. PHOTO: TRÉHU ET AL., 2003.

CORE SAMPLES FROM THE HIKURANGI SUBDUCTION ZONE OFF THE COAST OF NEW ZEALAND. THE SAMPLES SHOW A MISH-MASH OF ROCKS, WHICH MAY INFLUENCE EARTHQUAKE RISK.

Eclectic Rocks Influence Earthquake Types

Marine Geosciences

New Zealand's largest fault is a jumble of mixed-up rocks of all shapes, sizes, compositions and origins. According to research from a global team of scientists, this motley mixture could help explain why the fault generates slow-motion earthquakes known as "slow slip events" as well as destructive, tsunami-generating tremors.

"These rocks that are being mashed up together all behave very differently in terms of their earthquake generating potential," said Laura Wallace, a research scientist at the University of Texas Institute for Geophysics (UTIG) and co-chief scientist on the 2018 expedition that retrieved the rock samples.

The finding, described March 25, 2020, in *Science Advances,* is the latest discovery to emerge from two scientific drilling expeditions conducted in 2017 and 2018 in New Zealand and led by UT scientists and colleagues at institutions in New Zealand.

Subduction zones are where the world's largest and most damaging earthquakes occur. Scientists have long debated why quakes are more powerful or more frequent at some subduction zones than at others, and whether there may be a connection with the slow slip events, which can take weeks or months to unfold.

To answer these questions, scientists led ocean drilling expeditions off the coast of New Zealand, where they recovered rocks from the vicinity of the tremors' source by drilling into the remains of an ancient sea mountain.

"The earthquake and geological science community has speculated about what goes into a subduction zone where slow earthquakes occur, but this was the first time we've literally held those rocks—and physical evidence for any of those ideas—in our hands," said UTIG Director Demian Saffer, who was co-chief scientist on the 2018 expedition.

Efforts to understand the connection between slow slip events and more destructive earthquakes are already underway. These UTIG-led studies include detailed seismic imaging of the slow slip zone in New Zealand and an ongoing effort to track the behavior of subduction zones around the world by installing sensors on and beneath the seafloor. The goal of the work is to develop a better understanding of the events that lead up to a slow slip event versus a tsunami-generating earthquake.

The research was supported by the International Ocean Discovery Program; New Zealand's Ministry for Business, Innovation & Employment; NIWA; and GNS Science.

Patterns in Permafrost Soils Could Help Climate Change Models

Surface & Hydrologic Processes

The Arctic covers about 20% of the planet. But almost everything hydrologists know about the carbon-rich soils blanketing its permafrost comes from very few measurements taken just feet from Alaska's Dalton Highway.

The small sample size is a problem, particularly for scientists studying the role of Arctic hydrology on climate change. Permafrost soils hold vast amounts of carbon that could turn into greenhouse gasses. But the lack of data makes it difficult to predict what will happen to water and carbon as the permafrost melts due to warming temperatures.

New research led by the Department of Geological Sciences may help solve that problem.

Scientists spent four summers measuring permafrost soils across a 5,000-square-mile swath of Alaska's North Slope, an area about the size of Connecticut. While they worked to build up a much-needed soil data set, their measurements revealed an important pattern: The hydrologic properties of different permafrost soil types are very consistent and can be predicted based on the surrounding landscape.

"There is a vast swath of land that is eminently predictable," said Michael O'Connor, who led the research while earning a doctoral degree at the Jackson School of Geosciences. "Our paper shows that over an enormous study area, these very simple patterns in these properties hold true."

The study was published June 4, 2020, in the journal *Geophysical Research Letters*. Co-authors include researchers from the Jackson School, UT's Cockrell School of Engineering, Utah State University and the University of Michigan.

The researchers examined nearly 300 soil samples from different types of terrain. They found that soil types and their thickness are closely associated with the landscape, with the researchers classifying the landscapes into five categories based on the dominant vegetation and whether the environment was on a hill slope or near the bottom of a river valley.

They also found that each of the three soil types had distinct properties that affected how easily the soil could transfer heat and water—which determine how carbon dioxide and methane, another powerful greenhouse gas, are released.

The findings will allow scientists to look to the landscape to understand how carbon and greenhouse gases are moving through the soil below. Although the study does not make predictions about carbon release, co-author and Jackson School Professor Bayani Cardenas said that it provides a research framework.

"Our data fills a knowledge gap that has been around for 30 years," Cardenas said. "The community studying permafrost and climate change will appreciate its inherent value."

MICHAEL O'CONNOR, THEN A DOCTORAL CANDIDATE, COLLECTING A SAMPLE OF PERMAFROST SOIL IN ALASKA.

PHOTO: BAYANI CARDENAS.

Making Sense of Mudrocks

Energy Geosciences

A computer program created at the Bureau of Economic Geology is speeding up rock core analysis in mudrocks.

Called CorePy, the program automatically organizes geochemical and geomechanical data points into graphics that showcase the statistical distribution of important rock attributes in real time. The raw data is collected from the core through high-resolution X-ray fluorescence scanning.

Researchers at the bureau's Mudrock Systems Research Lab team used the programming language Python to create the program, which applies K-means clustering to integrate data analytics with graphical visualization.

"High-resolution X-ray fluorescence is a powerful geochemical tool used to characterize geological core, but geologists have struggled to fully utilize the large multivariate data sets that it generates," said Research Associate Toti Larson, who leads research at the lab. "The application allows researchers to integrate these complex data sets and visualize the results directly on core photographs, and to apply new data analysis tools, quickly visualize the results and better characterize the core."

The team has collected core data sets from samples from the Eagle Ford Shale, Permian Basin, Vaca Muerta Formation, Haynesville, Barnett and other mudrock plays.

In addition to Larson, the research team included Priyanka Periwal and Evan Sivil, both research scientist associates, and graduate student Esben Pedersen.

THE NILE RIVER IN CAIRO, EGYPT.

PHOTO: NINA R./FLICKR.

Mantle Keeps Ancient Nile on Course

Solid Earth & Tectonic Processes

If it were not for a hot upwelling of mantle rock in northern Africa, human history may have taken a different course. That's because without that upwelling, the Nile River almost certainly would have.

For millions of years, the Nile has kept the same steady northward path—an unusual behavior since long-lived rivers generally move over time. Research led by the Jackson School of Geosciences has found that movement of underlying mantle rocks has maintained the Nile's unique underlying landscape and enabled the river to stay the course. Without the influence of the mantle rocks, the river would have turned west long ago.

The research, published Nov. 11, 2019, in the journal *Nature Geoscience*, also revealed that the Nile is much older than anyone thought, with the scientists estimating the age of the Nile to be 30 million years—about six times as old as previously thought.

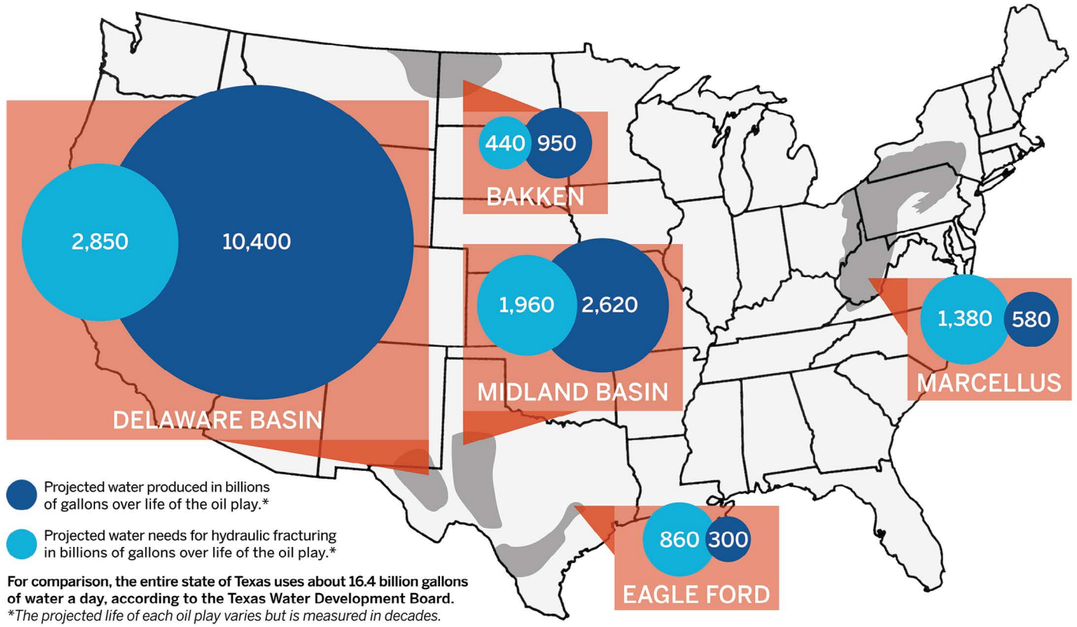
"One of the big questions about the Nile is when it originated and why it has persisted for so long," said Claudio Faccenna, a professor in the Department of Geological Sciences who led the research. "Our solution is actually quite exciting."

The results should settle a long-running debate about the age of the river and provide evidence that the slow movement of the deep mantle is one of the key forces shaping our Earth's landscape and geological processes.

The international research team also included Jackson School scientists Petar Glisovic, who is now a research collaborator at the University of Quebec; and Thorsten Becker, a professor in the department and research scientist at the University of Texas Institute for Geophysics.

In the paper, the researchers connected the tilted nature of the Nile's topography to a conveyor belt of mantle rock pushing up against the Ethiopian Highlands in the south and pulling the surface down in the north. The research involved studying ancient volcanic rock in the Ethiopian Highlands and correlating it with enormous deposits of river sediment buried under the Nile Delta.

The team verified their findings using computer simulations that re-created 40 million years of Earth's plate tectonic activity. The model showed the arrival of a hot mantle plume that probably led to the outpouring of lava that formed the Ethiopian Highlands while activating a conveyor belt in the mantle that persists to this day. The simulation reproduced changes in the landscape almost exactly as the scientists had expected—including small details in the landscape such as whitewater rapids found along the length of the Nile.



Water Reuse Could be Key for Future of Hydraulic Fracturing

A COMPARISON OF PROJECTED WATER NEEDS VERSUS PROJECTED WATER PRODUCED FOR MAJOR SHALE PLAYS.

Energy Geosciences

A lot of water is produced alongside oil and gas in unconventional reservoirs, a situation that raises a longstanding question: What to do with it all?

Two new studies, both published in February 2020, crunched the numbers around produced water and its potential uses to come up with an answer.

According to their work, enough water will be produced as a byproduct of oil production to theoretically counter the need to use fresh water for hydraulic fracturing in many of the nation's largest unconventional shale plays. Furthermore, while other industries, such as agriculture, might want to recycle some of that water for their own needs, water quality issues and the potential costs involved mean it could be best to keep the water in the oil patch.

"We need to first maximize reuse of produced water for hydraulic fracturing," said Bridget Scanlon, lead author on both of the studies and a senior research scientist with the Bureau of Economic Geology. "That's really the message here."

The first study, published in *Environmental Science and Technology,* quantifies for the first time how much water is produced by oil and natural gas operations compared with how much is needed for hydraulic fracturing. The authors also projected water demand for hydraulic fracturing needs and produced water during the life of the oil and gas plays, which span decades.

The second study assesses the potential for using the water produced by oil and natural gas in other sectors such as agriculture. It was published in *Science of the Total Environment* and shows that current volumes of produced water are relatively small compared with irrigation water demands and will not solve water scarcity issues.

The research looked at eight major plays across the U.S., including the Permian (Midland and Delaware), Bakken, Barnett, Eagle Ford, Fayetteville, Haynesville, Marcellus and Niobrara plays.

The scientists used historical data from 2009 to 2017 for all plays, and projections were developed for the life of the oil plays based on the technically recoverable oil using current technology. Oil plays produced much more water than natural gas plays, with the Permian Basin producing about 50 times as much water as the Marcellus in 2017. As far as recycling potential for hydraulic fracturing, the research shows that in many cases there's plenty of water that could be put to good use. For instance, in the Delaware Basin, which is part of the larger Permian Basin in Texas, scientists found that projected produced water volumes will be almost four times as great as the amount of water required for hydraulic fracturing.

Managing this produced water will pose a significant challenge in the Delaware, which accounts for about 50% of the country's projected oil production. Although the water could theoretically be used by other sectors, such as agriculture in arid West Texas, scientists said water quality issues and the cost to treat the briny water could be hurdles. In addition, if the water were highly treated to remove all the solids, large volumes of salt would be generated. The salt from the produced water in the Delaware Basin in 2017 alone could fill up to 3,000 Olympic swimming pools.

PHOTO: JACKSON SCHOOL.

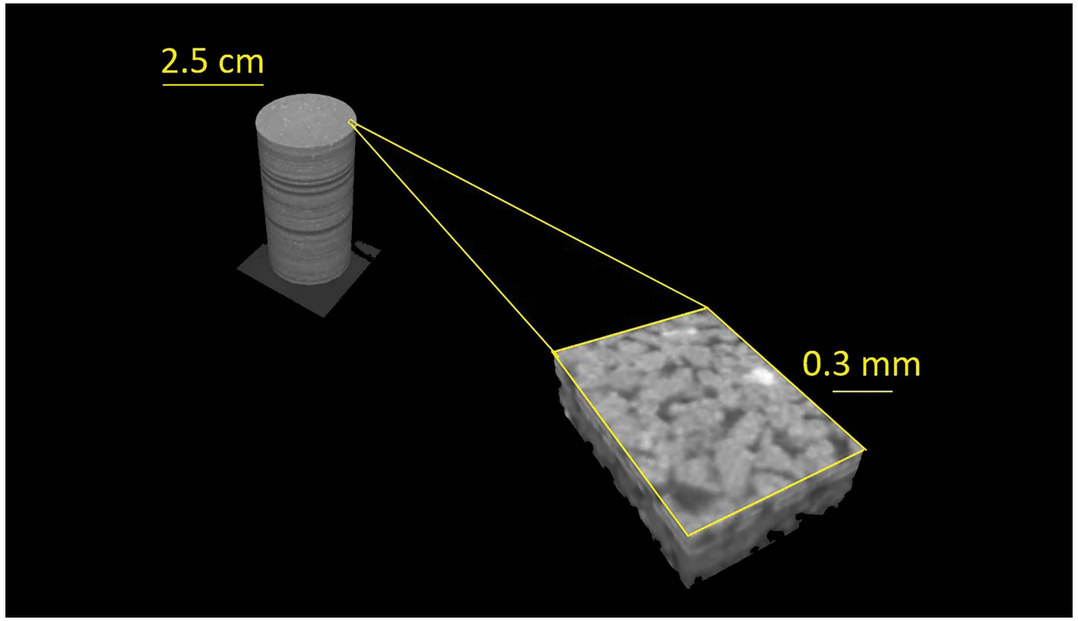


PHOTO: ERIC GOLDFARB.

ABOVE: A FIGURE ILLUSTRATING HOW CT-SCANNING TECHNOLOGY ENABLES DETAILED INVESTIGATION OF ROCK SAMPLE GRAINS.

Building a Better Rock Model

Solid Earth & Tectonic Processes

Once you crush, cut or fracture a rock, there are no do-overs. It's a fact that means geoscientists have to be particularly careful about which rock samples they can sacrifice to physics experiments versus which ones should stay on the shelf.

A team of researchers from the Department of Geological Sciences is working to change that with a new method for creating digital replicas of rock samples that is more accurate and simpler to use than other techniques.

The digital replicas can take the place of the real thing in certain experiments, allowing scientists to learn about rock samples without having to touch them. They also allow scientists to collect data from samples that are too small to run certain experiments on, such as cuttings brought up when drilling for oil.

"Now we don't have to take a rock into the lab," said Ken Ikeda, a graduate student at the Jackson School of Geosciences. "We don't have to risk a sample. There's no way to ruin it."

Ikeda is the lead author of a paper published June 8, 2020, in the *Journal of Geophysical Research: Solid Earth* that describes the new method. The other two authors are Jackson School graduate student Eric Goldfarb and Assistant Professor Nicola Tisato.

In their study, the researchers tested their method against two others, comparing how the three techniques fared at calculating how fast seismic waves moved through a sample. The new method came closest to the speeds measured in the actual sample, with the calculation being off by 4.5%. The other methods were off by 4.7% and 29%.

Seismic velocity data is a fundamental tool used by geoscientists to learn about rock formations underground. But the researchers said their method could be used for calculating a number of other important rock properties, such as permeability or electrical conductivity.

Climate Change Could Reawaken Indian Ocean El Niño

Climate & Environment

Global warming is approaching a tipping point that during this century could reawaken an ancient climate pattern similar to El Niño in the Indian Ocean, new research led by scientists from the University of Texas Institute of Geophysics (UTIG) has found.

If it comes to pass, floods, storms and drought are likely to worsen and become more regular, disproportionately affecting populations most vulnerable to climate change.

Computer simulations of climate change during the second half of the century show that global warming could disturb the Indian Ocean's surface temperatures, causing them to rise and fall year to year much more steeply than they do today. The seesaw pattern is strikingly similar to El Niño, a climate phenomenon that occurs in the Pacific Ocean and affects weather globally.

"Our research shows that raising or lowering the average global temperature just a few degrees triggers the Indian Ocean to operate exactly the same as the other tropical oceans, with less uniform surface temperatures across the equator, more variable climate, and with its own El Niño," said lead author Pedro DiNezio, a research scientist at UTIG (now an associate professor at the University of Colorado Boulder).

According to the research, if current warming trends continue, an Indian Ocean El Niño could emerge as early as 2050.

The results were published May 6, 2020, in the journal *Science Advances*. They build on a 2019 paper by many of the same authors that found evidence of a past Indian Ocean El Niño hidden in the shells of microscopic sea life, called forams, that lived 21,000 years ago—

the peak of the last ice age when the Earth was much cooler.

To show whether an Indian Ocean El Niño can occur in a warming world, the scientists analyzed climate simulations, grouping them according to how well they matched present-day observations. When global warming trends were included, the most accurate simulations were those showing an Indian Ocean El Niño emerging by 2100.

TOP: BUSHFIRES DARKENED THE SKY DURING AUSTRALIA'S "BLACK SUMMER" OF 2019-20. IF GLOBAL WARMING REAWAKENS AN INDIAN OCEAN EL NIÑO, SIMILAR EVENTS COULD BECOME MORE FREQUENT.
BOTTOM: FORAM SHELLS CONTAINING EVIDENCE OF AN INDIAN OCEAN EL NIÑO DURING THE LAST ICE AGE.

BUSHFIRES: INDIGO SKIES PHOTOGRAPHY/FLICKR. FORAM SHELLS: KAUSTUBH THIRUMALAI.

Leaking Pipes Feeding Austin Watershed

Surface & Hydrologic Processes

If it weren't for leaky city pipes and irrigation, it's possible that less water would be flowing through popular Austin swimming holes

Research from the Jackson School of Geosciences has found that in urbanized areas, much of the water that flows through Bull Creek—which feeds Bull Creek District Park and St. Edward's Park swimming holes—can be traced to municipal sources, such as sprinkler runoff and leakage from municipal water and wastewater pipes.

"That means if you turned off all the leakage and the irrigation, then some urbanized regions of Bull Creek and its tributary channels would lose a large amount of stream flow, more than 50% during non-rainstorm conditions," said lead author Lakin Beal, who conducted the research while earning a master's degree at the Jackson School. She is now a hydrogeologist at INTERA Inc.

The study was published in the journal *Water Resources Research* in February 2020 and is part of UT's Planet Texas 2050 initiative, which looks to Texas research as a model for solving environmental challenges facing the globe.

The findings raise concern about water quality in the watershed over time. Elevated sodium and chloride concentrations in urban areas suggest that wastewater is reaching the stream and spring water that flows naturally through the watershed.

The results also showcase a promising new geochemical technique that could help other cities learn more about their watersheds, said co-author Jay Banner, a professor in the Department of Geological Sciences.

"To recognize that the municipal water is getting out there, that's not a surprise because every city is leaking. But what is novel is the way we are able to chemically identify it and track how it changes," said Banner, who is also director of UT's Environmental Science Institute and an organizer of Planet Texas 2050.

The scientists were able to distinguish municipal water from natural water by looking for differences in the isotope signatures of strontium in the urban stream and spring water. Strontium is a trace element found naturally in Austin's underlying limestone bedrock, with the strontium from Austin's municipal water supply, which comes from the Highland Lakes, having an isotope signature different from that of the local groundwater.

The study points out other areas where water interacts with bedrock geology that has a distinctive chemical signature—such as St. Louis, Missouri, and Spokane, Washington—as good candidates for applying the technique.

"That underscores what the goal of the Planet Texas 2050 project is about," Banner said. "We want our results to be transferable."

ABOVE: WASTEWATER DRIVES MUCH OF THE FLOW IN AUSTIN'S BULL CREEK, A POPULAR SWIMMING HOLE.

PHOTO: AUSTIN PARKS FOUNDATION.

Iron Snow at Earth's Core

Solid Earth & Tectonic Processes

The Earth's inner core is hot, under immense pressure and snow-capped, according to new research that could help scientists better understand forces that affect the entire planet.

The snow is made of tiny particles of iron, making them much heavier than any snowflake on Earth's surface. These particles fall from the molten outer core and pile on top of the inner core, covering the inner core in piles up to 200 miles thick.

The image may sound like an alien winter wonderland. But the scientists who led the research said it is akin to how rocks form inside volcanoes.

"The Earth's metallic core works like a magma chamber that we know better of in the crust," said Jung-Fu Lin, a professor in the Department of Geological Sciences and a co-author of the study, which was published in December 2019 in the *Journal of Geophysical Research: Solid Earth*.

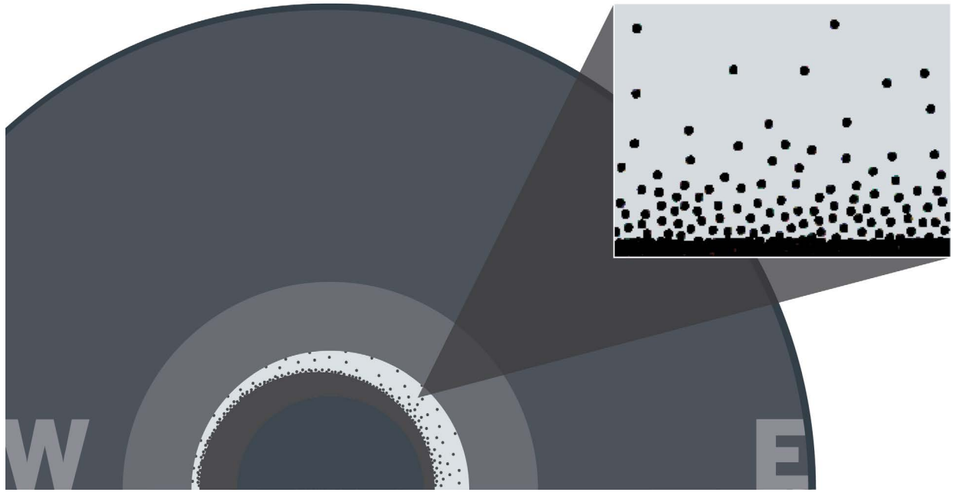
Youjun Zhang, an associate professor at Sichuan University in China, led the study. Other co-authors include Jackson School of Geosciences graduate student Peter Nelson and Nick Dygert, an assistant professor at the University of Tennessee who conducted the research during a postdoctoral fellowship at the Jackson School.

The Earth's core can't be sampled, so scientists study it by recording and analyzing signals from seismic waves as they pass through the Earth. Aberrations between recent seismic wave data and the data that would be expected based on the current model of the Earth's core have raised questions. The waves move more slowly than expected as they passed through the base of the outer core, and they move faster than expected when moving through the eastern hemisphere of the top inner core.

The study proposes the iron snow-capped core as an explanation for these aberrations. The scientist S.I. Braginskii proposed in the early 1960s that a slurry layer exists between the inner and outer core, but prevailing knowledge about heat and pressure conditions in the core environment quashed that theory. However, new data from experiments on core-like materials conducted by Zhang and pulled from more recent scientific literature found that crystallization was possible and that about 15% of the lowermost outer core could be made of iron-based crystals that eventually fall down from the liquid outer core and settle on top of the solid inner core.

"It's sort of a bizarre thing to think about," Dygert said. "You have crystals within the outer core snowing down onto the inner core over a distance of several hundred kilometers."

The researchers point to the accumulated snow pack as the cause of the seismic aberrations. The slurry-like composition slows the seismic waves. The variation in snow pile size—thinner in the eastern hemisphere and thicker in the western—explains the change in speed.



A SIMPLIFIED GRAPHIC OF THE INNER EARTH AS DESCRIBED BY THE NEW RESEARCH. THE WHITE AND BLACK LAYERS REPRESENT A SLURRY LAYER CONTAINING IRON CRYSTALS. THE IRON CRYSTALS FORM IN THE SLURRY LAYER OF THE OUTER CORE (WHITE). THESE CRYSTALS "SNOW" DOWN TO THE INNER CORE, WHERE THEY ACCUMULATE AND COMPACT INTO A LAYER ON TOP OF IT (BLACK). THE COMPACTED LAYER IS THICKER ON THE WESTERN HEMISPHERE OF THE INNER CORE (W) THAN ON THE EASTERN HEMISPHERE (E).

PHOTO: JACKSON SCHOOL.

Understanding History Through Sediment Patterns

Solid Earth & Tectonic Processes

Forces that shape the Earth's surface are recorded in a number of natural records, from tree rings to cave formations.

In a recent study, researchers at the Bureau of Economic Geology show that another natural record—sediments packed together at basin margins—offers scientists a powerful tool for understanding the forces that shaped the planet over millions of years.

The study, published in the journal *Geology*, uses a computer model to connect distinct patterns in the sedimentary deposits to shifts in climate and tectonic activity.

"We are trying to find a way to distinguish the tectonics and the climate signals," said lead author Jinyu Zhang, a research associate at the bureau. "By using this numerical model, we suddenly have this power to simulate the world under different tectonics and climate."

Zoltán Sylvester and Jacob Covault, both research scientists at the bureau, co-authored the paper.

Geoscientists have long looked to sedimentary basins for clues about Earth's past climate. That's because sediment supply is closely linked to environmental factors, such as rainfall or snowfall, that influence sediment creation through erosion and sediment transport. Tectonic factors also influence sediment creation, with increasing uplift associated with more sediment and decreasing uplift with less.

However, despite knowledge of sediment supply being linked with climate and tectonics, the researchers said little is known about how changes in these phenomena directly influence how sediment is deposited along basin margins over long time scales.

This study changes that, with Zhang using the open-source computer program pyBadlands to create a "source-to-sink" 3D model that tracks how changes in precipitation, tectonic uplift and sea level influence sediment erosion and deposition. The model uses topography inspired by the Himalaya Mountains and Indus River Delta to track sediment as it makes its way from the mountains through a river system and into a basin margin over millions of years.

"This is one of the first [models] to put the landscape evolution part with the stratigraphic response, depositional response, and do it in 3D," Covault said. "Jinyu has made a really great step in putting this all together."

The Search for Life

Planetary Sciences & Geobiology

Scientists from across The University of Texas at Austin are joining forces in the hunt for life on other planets.

Astronomers, geoscientists, chemists, biologists and aerospace engineers have pooled resources to form the UT Center for Planetary Systems Habitability, a cross-campus, interdisciplinary research unit.

Center co-director Sean Gulick, a research professor at the Jackson School of Geosciences, said that the new center will facilitate collaboration among scientists from different disciplines.

Researchers affiliated with the center are investigating how life on Earth has co-evolved with our planet, what makes a world habitable, and whether galactic scale conditions—such as star formation and supernovas—ultimately decide whether a planet can sustain life.

The center is looking for researchers from institutions outside of UT to collaborate on projects and is preparing to launch a visiting scholars program. It will also coordinate cross-campus, interdisciplinary teaching programs focused on planetary habitability.

By bringing researchers from different disciplines together, the center's founders hope to make the most of new planetary data from forthcoming missions and technology, such as NASA's James Webb Space Telescope. Interdisciplinary research is the best way to turn this data into breakthroughs, said Gulick.

"You have to get the astronomers who are studying exoplanets, together with the aerospace engineers designing missions together with the people who are doing the boots-on-the-ground research digging up extremophiles on Earth or finding analog processes," he said. "What the center can do is bridge these disciplines and give people a way to collaborate."

The center is a collaboration of UT's Jackson School, College of Natural Sciences, Cockrell School of Engineering and the Office of the Vice President for Research. Along with the diverse expertise, the center's scientists have access to campus resources such as the Visualization Laboratory at the Texas Advanced Computing Center, UT's Center for Space Research, and telescopes at the McDonald Observatory.

For more information, see ***habitability.utexas.edu.***

Ramping Up Carbon Capture

Climate & Environment

A study led by the Bureau of Economic Geology makes the case that trapping emissions underground could go a long way toward reducing global greenhouse emissions.

The study—from the Jackson School of Geosciences, the Norwegian University of Science and Technology, and the Equinor Research Centre—looks at the technology of carbon capture and storage (CCS), which is a method of capturing carbon dioxide from industrial and power plants and storing it more than a mile underground within tiny spaces in the rock.

The United Nation's Intergovernmental Panel on Climate Change (IPCC) has stated that CCS needs to achieve 13% of the world's necessary emission reductions by 2050. Some policymakers, industry representatives and nongovernment organizations are dubious that CCS can meet its portion of the goal, but the study published on Nov. 29, 2019, in *Nature Scientific Reports* shows that CCS could achieve the IPCC targets.

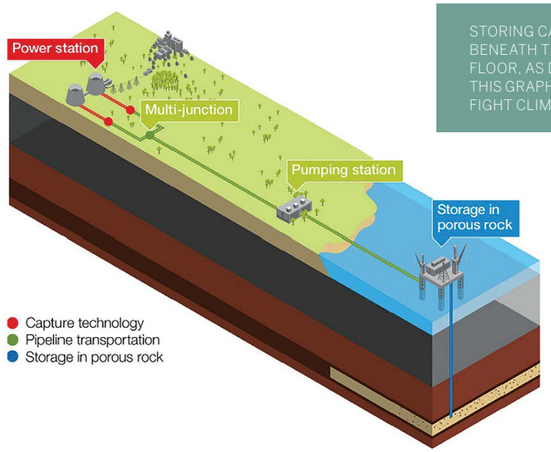
"With this paper, we provide an actionable, detailed pathway for CCS to meet the goals," said co-author Tip Meckel, a senior research scientist at the bureau. "This is a really big hammer that we can deploy right now to put a dent in our emissions profile."

The paper looks at the amount of geological space available in formations that are probably suitable to hold greenhouse gas emissions, keeping them from the atmosphere. It also calculates the number of wells needed worldwide to reach the IPCC's 2050 goal.

It concludes there is enough space in the word's nearshore continental margins to meet the IPCC's goal of storing 6 to 7 gigatons of CO_2 a year by 2050, and that the goal could be achieved by installing 10,000 to 14,000 injection wells worldwide in the next 30 years.

That may sound like a lot of wells, but the researchers point out that the oil and gas industry has already shown that speedy buildup of infrastructure is possible. Worldwide, the CCS deployment required during the next three decades would have to be about equivalent to the development of oil and gas infrastructure in the Gulf of Mexico during the past 70 years, or five times the development of Norwegian oil and gas infrastructure in the North Sea.

Meckel also pointed out that there are significant tax credits in the United States to help make carbon capture projects possible and said this could act as a model for other countries, particularly those with industries near the coast where CO_2 could be more easily transported by pipelines into underground, offshore geological formations.



STORING CARBON DIOXIDE BENEATH THE OCEAN FLOOR, AS DEPICTED IN THIS GRAPHIC, COULD HELP FIGHT CLIMATE CHANGE.

CARBON CAPTURE: UK DEPARTMENT OF ENERGY & CLIMATE CHANGE. MICROSENSORS: BUREAU OF ECONOMIC GEOLOGY.

Hydraulic Fracturing and West Texas Quakes

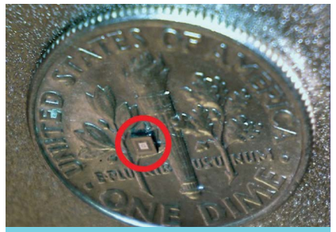
Energy Geosciences

A study by scientists from the TexNet Seismic Monitoring Program shows that some of the recent earthquake activity in the Delaware Basin of West Texas may be related to hydraulic fracturing.

"The research done through this new study in West Texas, using a statistical approach to associate seismicity with oil and gas operations, suggests that some seismicity is more likely related to hydraulic fracturing than saltwater disposal," said Alexandros Savvaidis, a research scientist at the Bureau of Economic Geology and manager of TexNet.

Hydraulic fracturing has been linked to seismicity in other areas—Oklahoma, China and Canada—but this study, published Oct. 14, 2019, in the *Journal of Geophysical Research: Solid Earth*, is the first to link it to induced seismicity in Texas.

The Delaware Basin is a part of the Permian Basin, a prolific oil and gas producing region that has seen a significant rise in exploration and production during the past few years. The Permian Basin now produces more than 5 million barrels of oil per day.



A 1-MM SENSOR ON A SINGLE CHIP WITH A DIME FOR SCALE.

CO_2 Microsensors

Energy Geosciences

In April 2020, the U.S. Department of Energy selected the Bureau of Economic Geology to lead a three-year project to track carbon dioxide underground with microsensors.

The goal of the $3.7 million grant is to improve scientists' understanding of how CO_2 travels underground by providing the department with real-time data and monitoring of subsurface CO_2 movement. For the project, co-principal investigators and bureau project managers David Chapman and Mohsen Ahmadian will develop and integrate wireless autonomous microsensor technology developed by the California Institute of Technology. The Research Triangle Institute and Sandia National Laboratories also developed project technology.

Microsensors will be deployed within a well casing annulus, the area between the wellbore and the casings. Researchers will use a wireless, solid-state sensor system to continuously measure CO_2, pH, temperature and methane within the high-pressure, high-temperature environment. The sensors are arranged on millimeter-size "sensors on a chip," that were developed by the bureau's Advanced Energy Consortium during the past eight years. These sensors consist of autonomous microelectronic radio-frequency tag circuits with memory and antenna that have been microfabricated on the sensor chips.

The sensor chips are wirelessly operated and inductively powered with smart casing collars containing routers that communicate to the surface. The project's goals include successfully conducting a fully integrated field laboratory validation of an integrated distributed wireless intelligent sensor system at the bureau's Intermediate Scale Field Test Lab in Devine, Texas.

PHOTO: BRITISH GEOLOGICAL SURVEY.

A FOSSIL OF THE OLDEST KNOWN MILLIPEDE, *KAMPECARIS OBANENSIS*.

The Oldest Bug

Planetary Sciences & Geobiology

A 425-million-year-old millipede fossil from the Scottish island of Kerrera is the world's oldest "bug"—older than any known fossil of an insect, arachnid or other related creepy-crawly, according to researchers at the Jackson School of Geosciences.

The findings offer new evidence about the origin and evolution of bugs and plants, suggesting that they evolved much more rapidly than some scientists believe, going from lake-hugging communities to complex forest ecosystems in just 40 million years.

"It's a big jump from these tiny guys to very complex forest communities, and in the scheme of things, it didn't take that long," said Michael Brookfield, a research associate at the Jackson School and adjunct professor at the University of Massachusetts Boston. "It seems to be a rapid radiation of evolution from these mountain valleys, down to the lowlands, and then worldwide after that."

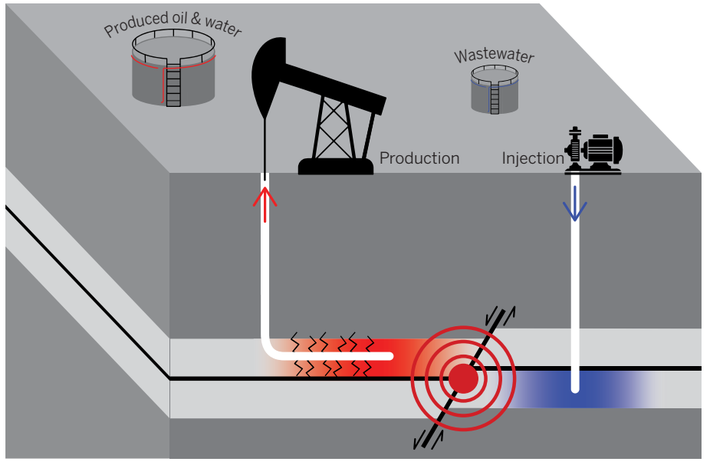
The research was published in May 2020 in the journal *Historical Biology*.

Brookfield led the study with co-authors including Elizabeth Catlos, an associate professor in the Department of Geological Sciences and Stephanie Suarez, a doctoral student at the University of Houston who made improvements to the fossil dating technique used in the study when she was an undergraduate at the Jackson School.

The team found that the ancient millipede fossil is 425 million years old, about 75 million years younger than the age other scientists have estimated the oldest millipede to be using a different technique known as molecular clock dating, which is based on DNA's mutation rate. Other research using fossil dating found that the oldest fossil of a land-dwelling, stemmed plant (also from Scotland) is also 425 million years old, about 75 million years younger than molecular clock estimates.

If that's the case, it means both bugs and plants evolved much more rapidly than the timeline indicated by the molecular clock. Bountiful bug deposits have been dated to just 20 million years later than the fossils. And by 40 million years later, there's evidence of thriving forest communities filled with spiders, insects and tall trees.

"Who is right, us or them?" Catlos said. "We're setting up testable hypotheses—and this is where we are at in the research right now."



Production Pressure

Energy Geosciences

The connection between oil and gas production and induced earthquakes is a hot research topic, with scientists studying which parts of the process are associated with increasing earthquake hazards.

While recent studies have shown that underground disposal of saltwater, a byproduct of oil and gas extraction, can increase the risk of earthquakes by raising pressure on nearby faults, the production of the oil and gas itself has been generally thought to lower that risk by relieving pressure.

But a study led by the Bureau of Economic Geology is challenging that thought. The study found that producing oil and gas from unconventional shale reservoirs near a fault could increase earthquake hazards by changing the stress felt by the fault.

According to the authors, their study illustrates the need to consider both disposal and production, and how the combined effects can influence earthquake hazards.

"It's not so simple to blame saltwater disposal in isolation. We can't ignore the effects of production," said Peter Eichhubl, a senior research scientist at the bureau.

The study was published Jan. 30, 2020, in the journal *Geomechanics for Energy and the Environment*. The authors are Eichhubl and bureau postdoctoral fellow Mahdi Haddad.

The research is based on a computational model of a simplified unconventional reservoir. The model allowed the researchers to track the stress changes on a fault as oil and gas were extracted from a shale layer and saltwater was disposed of in a different layer, an operations scenario known as a stacked reservoir.

In conventional oil and gas operations, the saltwater produced alongside oil and gas is disposed of by injecting it back into the same layer where the hydrocarbons were extracted, which helps stabilize pressure within the surrounding rock. In a stacked reservoir, the produced saltwater must be placed in a different, more porous rock layer because shale is unable to absorb injected water. This redistribution of pressure can change stress on nearby faults, which, in some cases, can make them slip.

To investigate how this practice affects nearby faults, the researchers used their model to track the stress exerted on a fault across 12 different scenarios and determine the stress conditions that caused the fault to slip for each scenario. In each scenario, the position of the production and disposal wells was changed to be either in a top or bottom layer, and the distance was changed to be closer or farther away from a fault. Each scenario was run until the fault slipped.

Some model outcomes were expected. For example, increasing the distance of wells from faults reduced the earthquake hazard. However, others were unexpected. For instance, disposing saltwater into a layer above the producing layer affects nearby faults differently than placing it below the producing layer. The most surprising result was that production near a fault can increase the risk of the fault slipping. Together, the various scenario outcomes illustrate how the combined effect of oil and gas production and saltwater disposal in the same area can create a complex stress environment.

The researchers emphasize that the scenarios produced by the model are simplified and should not be used to predict seismic hazard in an actual reservoir environment. Nevertheless, they said they hope the model can help serve as a guide toward new strategies to minimize the hazards of induced seismicity.

The research was funded by TexNet and the Center for Integrated Seismicity Research at the bureau.

ABOVE: A GRAPHIC DEMONSTRATING HOW CONCURRENT PRODUCTION AND WASTEWATER INJECTION CAN POTENTIALLY INCREASE THE RISK OF INDUCED SEISMICITY BY CHANGING THE STRESS ON A FAULT.

PHOTO: JACKSON SCHOOL.

Muffled Quakes

Marine Geosciences

A study published March 2, 2020, in *Nature Geoscience* has found that when mountains on the seafloor are pulled into subduction zones—places where one tectonic plate dives beneath another—they help set the stage for powerful earthquakes but also create conditions that end up dampening them.

"The earth ahead of the subducting seamount becomes brittle, favoring powerful earthquakes, while the material behind it remains soft and weak, allowing stress to be released more gently," said co-author Demian Saffer, director of the University of Texas Institute for Geophysics.

The findings mean that scientists should more carefully monitor particular areas around subducting seamounts, researchers said. The practice could help scientists better understand and predict where future earthquakes are most likely to occur.

The study was led by Tian Sun, a research scientist at the Geological Survey of Canada. Other co-authors include Susan Ellis, a scientist at the New Zealand research institute GNS Science. Saffer supervised the project and was Sun's postdoctoral adviser at Penn State when they began the study.

The researchers made the findings using a computer model of a subducting seamount. The model measured the effects on the surrounding rock and sediment, including the complex interactions between stresses in the earth and fluid pressure in the surrounding material. Getting realistic data for the model involved conducting experiments on rock samples collected from subduction zones by a scientific drilling mission off the coast of Japan.

The scientists said the model's results took them completely by surprise. They had expected water pressure and stress to break up material at the head of the seamount and thus weaken the rocks, not strengthen them.

While the weakened rock left in the wake of seamounts may dampen large earthquakes, the researchers believe that it could be an important factor in a type of earthquake known as a slow slip event. These slow-motion quakes are unique because they can take days, weeks and even months to unfold.

RIGHT: AN ARTIST'S INTERPRETATION OF A DILOPHOSAURUS DINOSAUR TENDING ITS NEST.

PHOTO: BRIAN ENGH.

No Frills for 'Jurassic Park' Dino

Planetary Sciences & Geobiology

From movies to museum exhibits, the dinosaur Dilophosaurus is no stranger to pop culture. Many probably remember it best from the movie "Jurassic Park," where it's depicted as a venom-spitting beast with a rattling frill around its neck and two paddle-like crests on its head.

The dinosaur in the movie is mostly imagination, but a new comprehensive analysis of Dilophosaurus fossils is helping to set the record straight. Far from the small lizard-like dinosaur in the movies, the actual Dilophosaurus was the largest land animal of its time, reaching up to 20 feet in length. It also had much in common with modern birds.

The analysis was published open access in the *Journal of Paleontology* on July 7, 2020.

Dilophosaurus lived 183 million years ago during the Early Jurassic. Despite big-screen fame, scientists knew surprisingly little about how the dinosaur looked or fit into a family tree, until now.

"It's pretty much the best, worst-known dinosaur," said lead author Adam Marsh. "Until this study, nobody knew what Dilophosaurus looked like or how it evolved."

Seeking answers to these questions, Marsh conducted an analysis of the five most-complete Dilophosaurus specimens while earning a Ph.D. at the Jackson School of Geosciences. He is now the lead paleontologist at Petrified Forest National Park.

The analysis is co-authored by Professor Timothy Rowe, who discovered two of the five Dilophosaurus specimens that Marsh studied.

Early descriptions characterize the dinosaur as having a fragile dual crest and weak jaws, a description that influenced the depiction of Dilophosaurus in the "Jurassic Park" book and movie as a svelte dinosaur that subdued its prey with venom.

But Marsh found the opposite. The jawbones show signs of serving as scaffolding for powerful muscles. He also found that some bones were mottled with air pockets, which would have helped reinforce the skeleton, including its crest.

Today, many species of birds use similar air sacs to inflate stretchy areas of skin. The intricate array of air pockets and ducts that extend from Dilophosaurus' sinus cavity into its crests means that the dinosaur may have been able to perform similar feats with its headgear.

All the specimens Marsh examined came from the Kayenta Formation in Arizona and belong to the Navajo Nation. The University of California Museum of Paleontology holds in trust three of the specimens. The Jackson School Museum of Earth History holds the two discovered by Rowe.

Field work on the Navajo Nation was conducted under a permit from the Navajo Nation Minerals Department.

Monster Egg

Planetary Sciences & Geobiology

In 2011, Chilean scientists discovered a mysterious fossil in Antarctica that looked like a deflated football. For nearly a decade, the specimen sat in the collections of Chile's National Museum of Natural History, with scientists identifying it only by its sci-fi movie-inspired nickname—"The Thing."

An analysis led by Lucas Legendre, a Jackson School of Geosciences postdoctoral researcher, has found that the fossil is a giant, soft-shell egg from about 66 million years ago. Measuring in at about a foot long, the egg is the largest soft-shell egg ever discovered and the second-largest egg of any known animal.

The specimen is the first fossil egg found in Antarctica and pushes the limits of how big scientists thought soft-shell eggs could grow. Aside from its astounding size, the fossil is significant because scientists think it was laid by an extinct, giant marine reptile, such as a mosasaur. The discovery challenges the prevailing thought that such creatures did not lay eggs.

"It is from an animal the size of a large dinosaur, but it is completely unlike a dinosaur egg," said Legendre.

A study describing the fossil egg was published in *Nature* on June 17, 2020.

Co-author David Rubilar-Rogers of Chile's National Museum of Natural History was one of the scientists who discovered the fossil in 2011. He showed it to every geologist who came to the museum, hoping somebody had an idea, but he didn't find anyone until Julia Clarke, a professor in the Department of Geological Sciences, visited in 2018.

"I showed it to her, and after a few minutes, Julia told me it could be a deflated egg!" Rubilar-Rogers said.

Using a suite of microscopes to study samples, Legendre found several layers of membrane that confirmed that the fossil was indeed an egg. Since the egg is hatched and has no skeleton, he had to use other means to zero in on the type of reptile that laid it.

By comparing the size of 259 living reptiles to the size of their eggs, Legendre came up with an estimate that puts the ancient egg layer at more than 20 feet long, not counting a tail. In both size and living reptile relations, an ancient marine reptile fits the bill.

Adding to that evidence, the rock formation where the egg was discovered also hosts skeletons from baby mosasaurs and plesiosaurs, along with adult specimens.

The paper does not discuss how the ancient reptile might have laid the eggs. But the researchers have two competing ideas.

One involves the egg hatching in the open water, which is how some species of sea snakes give birth. The other involves the reptile depositing the eggs on a beach.

The study's other co-authors are Clarke, Jackson School graduate students Sarah Davis and Grace Musser, and Rodrigo Otero and Alexander Vargas of the University of Chile.

ABOVE: AN ARTIST'S INTERPRETATION OF A BABY MOSASAUR HATCHING FROM AN EGG IN THE ANTARCTIC SEA. THE MOTHER IS VISIBLE IN THE BACKGROUND. THE EGG IS ON THE SEAFLOOR.

PHOTO: FRANCISCO HUEICHALEO.

Shaking West Texas

Solid Earth & Tectonic Processes

A new analysis of historical seismic data has found that earthquake activity in West Texas near the city of Pecos has increased dramatically since 2009.

The study, published in the *Journal of Geophysical Research: Solid Earth* on Nov. 4, 2019, leverages old, unmined data to track seismic activity over nearly 20 years—much further back than other studies—to show that activity has increased during the past decade in an area of the Permian Basin. Although researchers have generally thought that to be true, the statewide TexNet earthquake monitoring system has been gathering data since only 2017, making it impossible to definitively determine when the cluster of seismic activity around Pecos really began.

The researchers were able to extend the seismic record by turning to the older TXAR system near Lajitas, Texas, about 150 miles to the south. TXAR is an array of 10 seismographs installed in the 1990s by scientists at Southern Methodist University to help track nuclear testing across the world, said lead author Cliff Frohlich, a senior research scientist emeritus at the University of Texas Institute for Geophysics.

"Especially for these West Texas earthquakes, we would like to get some information about when they started," Frohlich said. "I really saw this as a way to bridge the gap before TexNet."

The TXAR system is some distance from Pecos, but Frohlich said the equipment is highly sensitive and that the area is remote and seismically very quiet, making the system perfect for picking up vibrations from explosions across the world or earthquakes 150 miles away.

Scientists were able to document more than 7,000 seismic events near Pecos that were determined by the team to be earthquakes. Multiple events first started occurring in 2009, when 19 earthquakes of at least magnitude 1 were documented. The rate increased over time, with more than 1,600 earthquakes of magnitude 1 or greater in 2017. Most were so small that no one felt them.

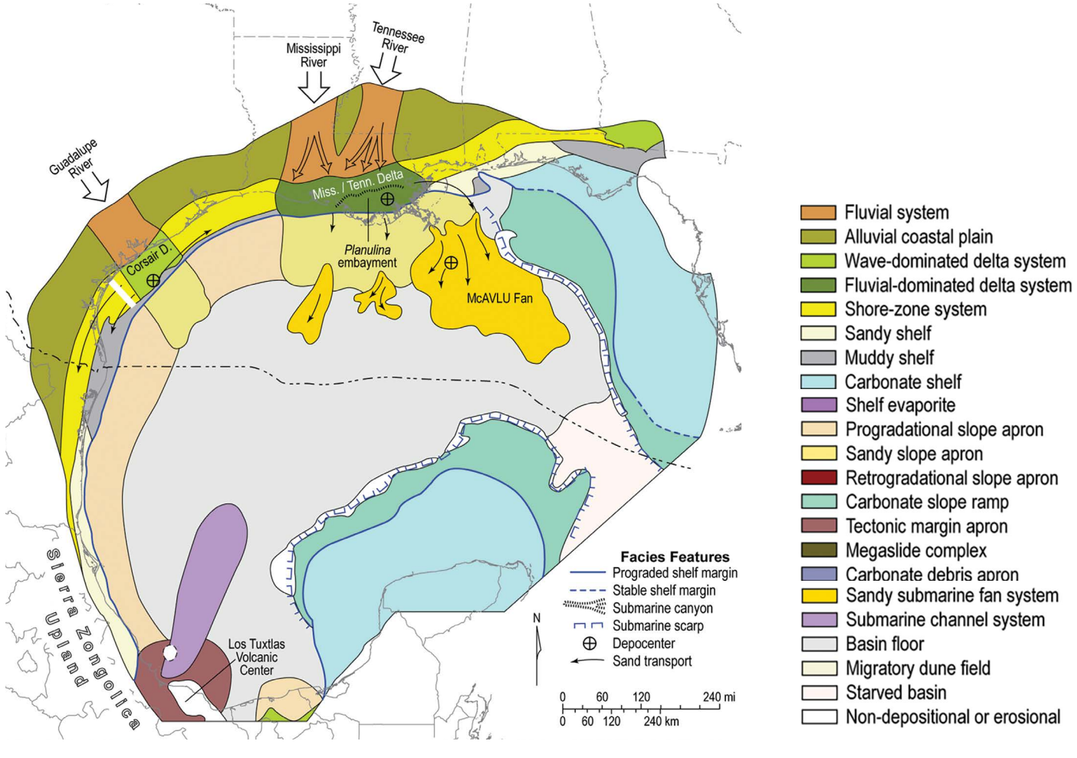
The study shows a correlation between earthquake activity and an increase in oil and gas activity, but it does not make an effort to directly tie the two together as other studies have done.

This study is the latest in a comprehensive effort to determine what is causing an increase in seismic activity in Texas and how oil and gas operations can be managed to minimize the human-induced element. The state approved the TexNet system in 2015. It is operated in tandem with research efforts by the Center for Integrated Seismicity Research (CISR).

"The obvious next step is exactly what the University of Texas is doing—conducting these careful studies on the relationship between earthquakes and their human and natural causes to build an integrated understanding," said co-author Peter Hennings, who leads CISR and is a research scientist at the Bureau of Economic Geology.

ABOVE: AERIAL VIEW OF THE PERMIAN BASIN.

PHOTO: BRUCE GORDON/FLICKR.



GBDS Expands to Entire Gulf

Marine Geosciences

For 25 years, an industry-sponsored research project led by the University of Texas Institute for Geophysics (UTIG) has provided its members with a depositional history of the offshore northern Gulf of Mexico. Starting in January 2020, UTIG's Gulf Basin Depositional Synthesis (GBDS) program expanded its scope, offering members an analysis of the entire basin, including the southern Gulf and onshore regions.

"We've adapted as a research project by greatly expanding our portfolio," said program director John Snedden. "We are now in a position to satisfy a diverse set of interests, while maintaining leveraged advantage for our 26 members."

The program's primary scientific product is the GBDS Phase XII Atlas, which includes hundreds of cross sections and maps detailing the basin's depositional history. The atlas is updated each year and a new edition presented to industry members at the annual meeting.

Historically, oil and gas exploration in the northern Gulf of Mexico has surged as new techniques and better geological and geophysical understanding have helped unlock new energy reserves.

The southern Gulf of Mexico, which was closed to international exploration for decades, has been, so far, much less prolific. Much of this comes down to a lack of knowledge about the region's subsurface.

Until recently, the only available regional data came from seismic studies conducted by UTIG in 1976.

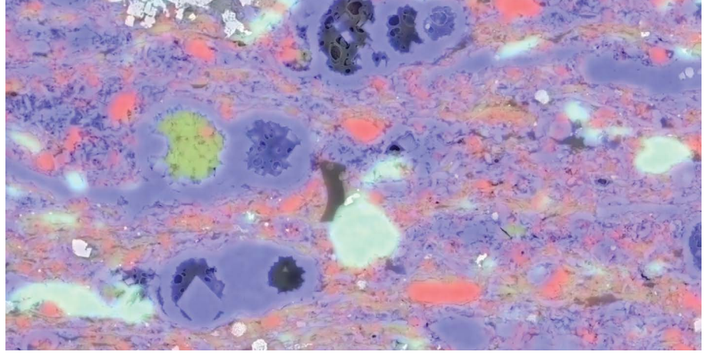
When the Mexican government decided in 2015 to allow foreign companies to explore its waters, GBDS's knowledge of the southern Gulf of Mexico was a unique resource for the industry.

Now, the program is leveraging this knowledge to offer expert analyses of data emerging from the southern basin.

By expanding into new waters and offering companies detailed onshore data, the program has reinvented itself and broadened its appeal in a way that reflects increasing diversification in the industry.

ABOVE: A DEPOSITIONAL MAP OF THE GULF OF MEXICO FROM THE GBDS ATLAS.

PHOTO: UNIVERSITY OF TEXAS INSTITUTE FOR GEOPHYSICS.



SEM IMAGE SHOWING AN ARGON-ION-MILLED SURFACE OF THE EAGLE FORD SHALE. IMAGE HAS BEEN COLOR CODED TO SHOW ELEMENTAL COMPOSITION. BLUE IS CALCITE, RED IS QUARTZ, GREEN IS CLAY, PURPLE IS DOLOMITE, AND AQUA IS FELDSPAR.

SEM Advancing Research

Energy Geosciences

The Bureau of Economic Geology has long been at the forefront in applying scanning electron microscope (SEM) technology to create detailed characterization of rocks.

The FEI Nova NanoSEM scope in its Scanning Electron Microscopy Laboratory is enabling groundbreaking discoveries at the nano scale by combining its own advanced scanning capacity with other analytical methods and cutting-edge sample preparation.

Researchers at the laboratory are combining the scope's high-resolution field emission with energy-dispersive X-ray spectroscopy and cathodoluminescence methodologies to gain valuable new insights into depositional environments, diagenesis, fracture systems, and the geological conditions, processes and resource distribution in hydrocarbon reservoirs.

This technique is aided by a process known as element mapping, which makes it possible to see where rock pores are in relation to the mineral phases of shales. This characteristic varies in different rocks, allowing scientists to use pore location to infer information about the various stages of maturation in different rock types.

Recent research demonstrated the benefit of this method in identifying magnesium in shale samples. X-ray fluorescence interpretations alone could not distinguish whether the mineral hosting the magnesium in the sample was chlorite or dolomite. But when false color was assigned to magnesium and added to an SEM image of a sample, the mineral hosting the magnesium could be easily seen and identified. This interpretation method has significant implications at a variety of scales, from microfractures, to fluid-flow studies, to reservoir characterization.

A sample preparation technique used by the lab is also helping shale studies by illuminating rock characteristics that are imperceptible using traditional SEM technologies. Argon milling creates a clean and smooth sample by shaving an extremely thin layer of material off the sample, with the resulting image revealing shale pore structures in amazing clarity.

PHOTO: BUREAU OF ECONOMIC GEOLOGY SCANNING ELECTRON MICROSCOPY LABORATORY.

Climate Change Increasing East African Rains

Climate & Environment

Seasonal rainfall is expected to rise significantly in East Africa during the next few decades in response to increased greenhouse gases, according to a study published in July 2020 in *Climate Dynamics*.

Researchers used high-resolution simulations to find that the amount of precipitation during the rainy season known as the "short rains" could double by the end of the century, continuing a trend that has already been observed in recent years. The season known as the "long rains," on the other hand, is expected to remain stable, according to the new projections. These results are in contrast to previous analyses that associated global warming with drier conditions that occurred earlier this century.

"There are two East African rainy seasons with different sensitivities to greenhouse gases," said lead author Kerry Cook, a professor in the Jackson School of Geosciences Department of Geological Sciences. "Our paper shows that the short rains will continue to increase—in fact, flooding and locust infestations are already occurring—and that there is no drying trend for the long rains."

The newly published simulations have a 30 kilometer resolution that resolves the complex East African topography and more accurately represent currently observed rainfall amounts and seasonality than coarser resolution global models. Simulations of rainfall through 2050 are consistent with currently observed rainfall amounts and seasonality.

"This research will allow people to plan ahead in East Africa," said Cook.

In addition to Cook, authors of this research include Ph.D. student Weiran Liu and Research Scientist Associate Edward Vizy also of the Department of Geological Sciences and Rory Fitzpatrick of the University of Leeds.

JORGE PIÑON, DIRECTOR OF THE JACKSON SCHOOL OF GEOSCIENCES CENTER FOR INTERNATIONAL ENERGY AND ENVIRONMENTAL POLICY, ON CNN EN ESPAÑOL.

QUEER EYE'S JONATHAN VAN NESS INTERVIEWED JACKSON SCHOOL PROFESSOR JULIA CLARKE ABOUT DINOSAURS IN PREHISTORIC AMERICA ON HIS PODCAST "GETTING CURIOUS WITH JONATHAN VAN NESS." THE EPISODE DEBUTED IN MAY BUT WAS RECORDED BEFORE THE COVID-19 PANDEMIC.

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.

Natural Gas Oversupply Results in Exceptionally Low Prices

"Demand for natural gas has been growing more than any other fuel in absolute terms. Over the past 40 years, gas use has increased more than 500% globally. That is a remarkable growth rate."

Scott Tinker
Director, Bureau of Economic Geology
MSN Money, June 6, 2020

Iron 'Snow' Could Be Falling in Earth's Core, Study Shows

"It's sort of a bizarre thing to think about. You have crystals within the outer core snowing down onto the inner core over a distance of several hundred kilometers."

Nick Dygert
Distinguished Postdoctoral Fellow, Department of Geological Sciences (now an Assistant Professor at the University of Tennessee)
Fox News, Dec. 20, 2019

Reusing Oil Field Wastewater is Key to Shale's Future, Researchers Say

"The water volumes that are quoted vary widely, that's why we did this study. This really provides a quantitative analysis of hydraulic fracturing water demand and produced water volumes."

Bridget Scanlon
Senior Research Scientist, Bureau of Economic Geology
San Antonio Express-News, Feb. 21, 2020

Dinosaur Asteroid's Trajectory was 'Perfect Storm'

"Also critical is that a 60-degree angle is in the range of the worst options for injecting large volumes of vaporised and ejected sulphur-rich rocks into the atmosphere. Thus these results are critical for understanding potential kill mechanisms."

Sean Gulick
Research Professor, University of Texas Institute for Geophysics and Department of Geological Sciences
BBC, May 26, 2020

Scientists Discover Ocean Carbon Dioxide Hotspot off Philippines

"These high carbon dioxide environments that are actually close to thriving reefs, how does it work? Life is still thriving there, but perhaps not the kind that we are used to. They need to be studied."

Bayani Cardenas
Professor, Department of Geological Sciences
Oceanographic Magazine, March 27, 2020

PIÑON: CNN EN ESPAÑOL. VAN NESS AND CLARKE: GETTING CURIOUS WITH JONATHAN VAN NESS.

Jackson School News: jsg.utexas.edu/news

UTJSG @TXGEOSCIENCES JSG UT AUSTIN @TXGEOSCIENCES

Arizona Rock Offers Clues to Chaotic Earth of 200 Million Years Ago

"The core lets us wind the clock back when the Petrified Forest National Park was a tropical hothouse populated by crocodile like reptiles and turkey-size early dinosaurs. We can now begin to interpret changes in the fossil record, such as whether changes at the time were caused by an asteroid impact or slow geographic changes of the supercontinent drifting apart."

Cornelia Rasmussen
Research Associate, University of Texas Institute for Geophysics
Mirage News Australia, July 20, 2020

A Deep-Sea Magma Monster Gets a Body Scan

"I don't think I've ever been on a cruise where everything goes smoothly. You're always losing instruments."

Adrien Arnulf
Research Associate, University of Texas Institute for Geophysics
New York Times, Dec. 3, 2019

Life Hatched From Soft Eggs, Some a Foot Long, in Dinosaur Era

"That's what really surprised us, because we didn't think that soft-shelled eggs could grow that big without collapsing. We didn't think there were animals that large that might have laid soft-shelled eggs."

Lucas Legendre
Postdoctoral Fellow, Department of Geological Sciences
New York Times, June 17, 2020

New Study Blames Some Permian Basin Earthquakes on Fracking

"The research done through this new study in West Texas, using a statistical approach to associate seismicity with oil and gas operations, suggests that some seismicity is more likely related to hydraulic fracturing than saltwater disposal."

Alexandros Savvaidis
Research Scientist, Bureau of Economic Geology
Houston Chronicle, Oct. 15, 2019

Texas Students Join Global Climate Strike

"With climate change, one of the predictions of climate science is that areas that are prone to extremes in the hydrological cycles, that is droughts and floods, will be prone to even more extremes, so more intense storms and more intense droughts. We've been seeing that. We've been seeing that in the last several years."

Jay Banner
Director, Environmental Science Institute
KETK, Sept. 20, 2019

Eclectic Rocks Influence Earthquake Types

"The next needed steps are to continue installing offshore instruments at subduction zones in New Zealand and elsewhere so we can closely monitor these large offshore faults, ultimately helping communities to be better prepared for future earthquakes and tsunami."

Laura Wallace
Research Scientist, University of Texas Institute for Geophysics
Science Daily, March 25, 2020

Climate Change may Kickstart Dormant El Niño Weather System in Indian Ocean

"The re-emergence will depend strongly on the rate of global warming, so ultimately on whether greenhouse gas emissions are abated or not. We are certain that the risks of these extreme events is becoming larger and larger as we pump more CO_2 into the atmosphere, and certainly going to have an unequal impact on countries in the tropics."

Pedro DiNezio
Research Scientist, University of Texas Institute for Geophysics (now Associate Professor at University of Colorado Boulder)
Independent, May 12, 2020

Scientists Find the Biggest Soft-Shelled Egg Ever, Nicknamed 'The Thing'

"It was weird enough that they decided to collect it, even though it wasn't clear what it was. It definitely wasn't bone, but it was strikingly unusual."

Julia Clarke
Professor, Department of Geological Sciences
NPR, June 17, 2020

The Best Fossils Need a Bit of Fresh Air to Form

"The cool thing about this work is that we can now understand the modes of formation of these different minerals as this organism fossilizes. A particular pathway can tell you about the oxygen conditions."

Rowan Martindale
Associate Professor, Department of Geological Sciences
Futurity, Nov. 6, 2019

FRACTURED WORLD

BY MONICA KORTSHA

THE FRAC GROUP IS MAKING STRIDES IN ANSWERING ONE OF GEOSCIENCES' LONGEST-STANDING PROBLEMS — UNDERSTANDING HOW ROCK FRACTURES FORM — BY STUDYING CRYSTALS INSIDE THE FRACTURES THEMSELVES.

PHOTO: A PANCHROMATIC SEM-CL IMAGE OF A PARTIAL QUARTZ CEMENT BRIDGE SHOWING CROSS-CUTTING CRACK-SEAL TEXTURES AND CONTEMPORANEOUS LATERAL CEMENTS. SAMPLE FROM THE TRAVIS PEAK FORMATION TIGHT-GAS SANDSTONE, EAST TEXAS. CREDIT: ESTIBALITZ UKAR.

Big and small, rock fractures are everywhere.

They give famous landmarks their character: Can you imagine Yosemite National Park's El Capitan or Big Bend's Casa Grande without their fractured rock faces?

But the fractures we see at the surface are just the tip of the iceberg. The ground beneath our feet is riddled with them, with fractures serving as conduits for subsurface fluids. This includes water in aquifers that can be tapped for drinking or irrigation, and the natural fluids that humans depend on for energy, such as oil, gas, and the hot water and steam that serve as sources of hydrothermal energy.

It also includes fluids that humans introduce into the subsurface, such as carbon dioxide that's injected into rocks to keep it out of the atmosphere and hydraulic fracturing fluid that taps into hydrocarbons by creating even more fractures.

The ubiquity of fractures means that any venture happening in the subsurface has to take them into account. But doing that is easier said than done, said Stephen Laubach, a senior research scientist at the Jackson School of Geosciences Bureau of Economic Geology. Despite fractures being an object of study for more than 100 years, scientists are still working out the basics of how they form.

"It's not a new problem," said Laubach. "But it is probably one of the most refractory problems in the sciences — which is why there are so few people who stick with it."

Figuring out how fractures work is the driving force of the Fracture Research and Application Consortium, better known as FRAC.

Laubach is the leader of FRAC. Since the mid-1990s, the group has brought together faculty members, research scientists, postdoctoral researchers and graduate students from the Jackson School and the Cockrell School of Engineering to tackle the fracture question from multiple vantage points, including lab experiments, computational models and fieldwork around the globe.

PHOTO: COLOR SEM-CL IMAGE OF A CATACLASTIC DEFORMATION BAND IN THE ENTRADA SANDSTONE, SAN RAFAEL SWELL, UTAH. OVERGROWTH QUARTZ APPEARS DARK BLUE.

OPPOSITE PAGE: ESTIBALITZ UKAR AND FIELD ASSISTANTS FROM ARGENTINIAN OIL COMPANY YPF STUDYING BED-PARALLLEL VEINS OF FIBROUS CALCITE IN THE VACA MUERTA FORMATION SHALE, NEUQUEN BASIN, ARGENTINA, IN 2015.

PHOTO: SARA ELLIOTT.

But this is far from a see-what-sticks approach. All the research at FRAC is united by an overarching idea that Laubach calls "structural diagenesis."

The term is meant to make structural and sedimentary geologists alike perk up. The two specialties focus on different aspects of geology, with structural geologists immersed in physics—the historical domain of fracture research—and sedimentary geologists, and others such as petrologists and geochemists, focused on the chemical reactions that, over time, turn sediments into stone, a process known as diagenesis.

Structural diagenesis is a combination approach. And it's frequently applied to a long-overlooked domain: crystals that line fractures, creating coatings, bridges and other mineral structures that record a fracture's life story while potentially influencing where it's off to next.

As an industrial affiliates consortium, FRAC depends on funding from industry partners along with research grants. The fact that the group can count oil giants, international geothermal companies and the U.S. Department of Energy's Office of Basic Energy Sciences (BES)—a research wing devoted to science at the atomic and molecular scale—among its funders speaks to the breadth of their work and its potential for advancing basic science and real-world applications.

"Steve's really unbelievably unique," said James Rustad, the geoscience division manager at the BES. "His observations do a lot to inform people looking mechanistically at laboratory samples."

Wayne Narr, who attended consortia meetings on behalf of Chevron since the consortia was founded until retiring in 2019, said he valued the FRAC group in part as a sounding board.

"A benefit for me as a fracture specialist is to have somewhere to bounce my ideas off of," Narr said. "I rarely came back from a meeting where I didn't exchange a few emails—whether I was giving them my thoughts or soliciting ideas about something."

PHOTO: ESTIBALITZ UKAR.

The Problem with Fractures

What makes fractures so notoriously difficult to study in the first place?

A big part of the problem is their ubiquity. They show up in every rock formation and create patterns that can look more or less the same even in rocks with drastically different geologic histories. The situation is a textbook example of what's known as "equifinality"—an end state that can be reached in a number of different ways.

Of course, you don't necessarily need to know a fracture's life story to judge how well it might transport fluids. When considering fractures as subsurface conduits, the critical questions often have to do with the present: Where are the fractures now? What sort of patterns do they form? Are they clear conduits for fluids or clogged with mineral deposits?

Unfortunately, the usual ways of interrogating the subsurface are a dead end when it comes to fractures, Laubach said. Most fracture networks are too fine to show up on seismic images. And he compares inferring large-scale fracture patterns from core samples as akin to "inferring the existence of Niagara Falls from a drop of water." Analyses of core to understand fracture timing and diagenesis are fundamentally important, but there is just no way to know whether a single core sample is representative or not.

Outcrop fractures do have some predictive potential for fractures in buried rocks of the same age, and in the same area. However, when looking at the fracture patterns alone, it's difficult to know whether they formed when the outcrop was at depth or something that occurred later, such as weathering. And it's challenging to know what new fractures and fillings the outcrop have accumulated since it was first exposed, said Senior Research Scientist Julia Gale.

"Even if two rocks are sedimentologically identical, their fractures can be very different, depending on how deep they were buried, for how long, and whether they have been brought back up to the surface by tectonic processes," she said.

The long list of issues makes it seem as if the ultimate problem with fractures is their complexity. But Laubach said that it's quite the opposite. The problem at the root of fracture research is the apparent simplicity of fracture patterns; they look familiar wherever you go. As far as patterning is concerned, a fracture from a shale play and a fracture on the sidewalk could be one and the same.

Much of the research at FRAC is dedicated to searching out specifics in fracture samples—the characteristics that set a particular fracture apart from the others and help researchers pin down their history and the history of the rocks that host it. This is where structural diagenesis comes in.

The term came into use thanks in part to Jackson School Professor and inaugural Dean William Fisher, who in the early 2000s was serving as the school's director when it was still part of

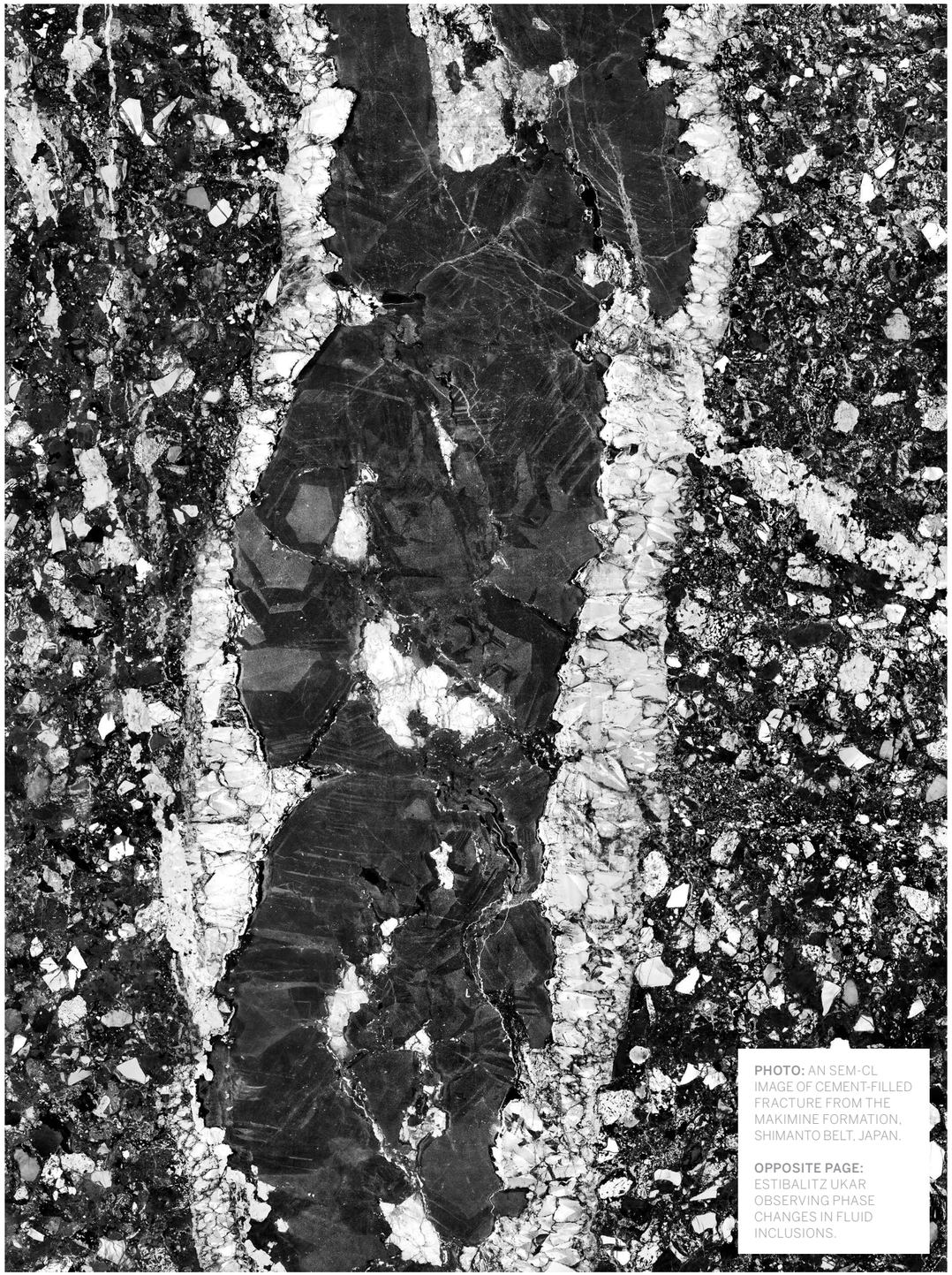


PHOTO: AN SEM-CL IMAGE OF CEMENT-FILLED FRACTURE FROM THE MAKIMINE FORMATION, SHIMANTO BELT, JAPAN.

OPPOSITE PAGE: ESTIBALITZ UKAR OBSERVING PHASE CHANGES IN FLUID INCLUSIONS.

PHOTO: SARA ELLIOTT.

the UT College of Natural Sciences. At this time, Fisher challenged researchers across the school's three units—the Department of Geological Sciences, the Bureau of Economic Geology and the University of Texas Institute for Geophysics—to come up with big ideas in science that funds from the school's newly established Jackson endowment could help get off the ground.

Laubach—working closely with then-Associate Professor Jon Olson (now professor and the chair of UT's Hildebrand Department of Petroleum and Geosystems Engineering), Professor Randy Marrett (now professor emeritus) and Gale—responded to the call, with the team coming up with structural diagenesis as an all-encompassing term to describe their research goals.

"We came and said 'we have got something. We're going to found a new discipline,'" Laubach said. "We're going to break through the walls, the silos, because there's a fundamental problem, and this is the way to solve it—and we're going to call it structural diagenesis."

Fisher accepted the pitch (contingent on the group ponying up half the funds from industry supporters), and the FRAC consortia, which had been running for four years on industry support alone, got its startup funds.

"You had to establish a pretty good research record, and these folks had one," Fisher said.

Put simply, structural diagenesis turns fractures from nonspecific patterns into objects with unique histories to be uncovered. It does that by investigating both the mechanics of fracture pattern formation and the chemical record preserved inside the fractures themselves.

This chemical perspective has historically been overlooked in fracture research—an outcome of fractures being primarily framed as a mechanics problem, Laubach said. However, the crystal coatings that line fracture walls offer a wealth of information that mechanics simply can't provide. They serve as a chemical record, preserving details about timing, temperatures and fluids. They provide an opportunity for the problem of equifinality to be overcome.

Crystals form most readily in rocks buried anywhere from less than a half-mile to about nine miles underground, where hot temperatures, high pressures and reactive fluids catalyze chemical reactions that make minerals precipitate on fracture walls. The fact that these are the same rocks where a number of industries are most active—whether it's pulling fluids out of the ground or looking for space to store them—makes getting specific about fractures in this area of the subsurface especially relevant.

Laubach is a big Sherlock Holmes fan, and he said that the story of the "Red-Headed League" has lessons for anyone looking to understand why FRAC focuses on structural diagenesis. In the story, Holmes remarks how the "simple crimes" are the hardest to solve because they offer few clues, while the bizarre crimes are easier because they offer more.

PHOTO: ANDRÁS FALL.

"Natural fractures are a simple crime," Laubach said. "Structural diagenesis turns it into the 'Red-Headed League' [by providing more clues]."

Structural Diagenesis in Action

Collectively, the FRAC group has produced hundreds of studies over the decades. The work is diverse and includes outcrop investigations from around the world, computational models, lab analyses and in many cases, a mix of all three.

Among the most notable studies are those that have uncovered insights on fracture behavior that can apply across environments.

One of these is a 2015 paper published in the *Geological Society of America Bulletin* and authored by Laubach and collaborator Rob Lander, a research fellow at the bureau and co-founder of the geosciences software company Geocosm. The paper describes how quartz crystal growth patterns inside sandstone correlate with fracturing events, and it presents a model for simulating how these patterns are expected to grow under different fracturing regimes. The research team uses the model to successfully reconstruct the formation of a quartz bridge that spans a fracture space in a core from the Cretaceous Travis Peak Formation in the East Texas Basin, with the conditions being confirmed with a detailed lab analysis of the quartz structure. All in all, the close matchup between the model and the experiments meant that it could serve as an alternative means for determining key attributes about fracture formation, including constraining fracture opening rates and the temperatures under which the fractures were active.

Oddly enough, the existence of the quartz bridge structure that helped demonstrate the model surprised Lander when Laubach first showed him the structure in 2004 when the two got together to talk about quartz structures. Laubach wasn't fazed by it. As a structural geologist, the quartz filling seemed similar enough to quartz veins he had observed in metamorphic rocks. Lander, on the other hand, said that the structure should be impossible

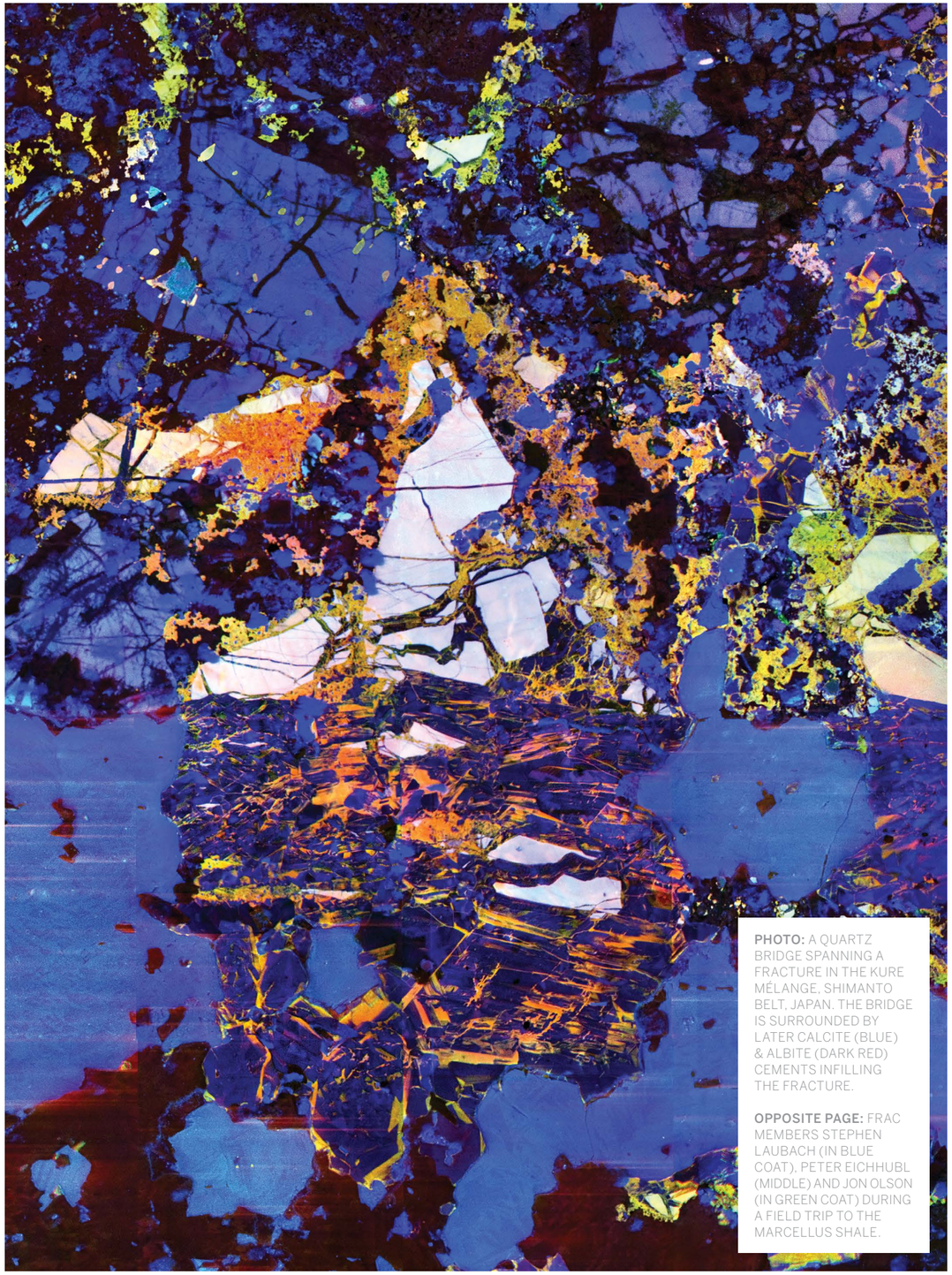


PHOTO: A QUARTZ BRIDGE SPANNING A FRACTURE IN THE KURE MÉLANGE, SHIMANTO BELT, JAPAN. THE BRIDGE IS SURROUNDED BY LATER CALCITE (BLUE) & ALBITE (DARK RED) CEMENTS INFILLING THE FRACTURE.

OPPOSITE PAGE: FRAC MEMBERS STEPHEN LAUBACH (IN BLUE COAT), PETER EICHHUBL (MIDDLE) AND JON OLSON (IN GREEN COAT) DURING A FIELD TRIP TO THE MARCELLUS SHALE.

PHOTO: SARA ELLIOTT.

PHOTO: JULIA GALE.

under the diagenetic conditions of a sedimentary basin. A study published later that year explained the chemistry that enabled this type of growth—and helped the FRAC group cinch their first big grant for the DOE's Office of Basic Energy Science while laying the groundwork for the 2015 paper.

Laubach said that the experience illustrates the importance of structural diagenesis's blended perspective.

"I didn't have the right sort of theoretical underpinning to look at it and realize it was a problematic structure, and Rob did, but of course he was a diagenesis guy, and so he never looked at fractures before," he said. "It was a cross-disciplinary moment."

Quartz bridges have proved to be a key fracture feature when undertaking structural diagenetic investigations. That's because they don't form in a single instance. Instead, they grow a little more each time in response to microfracturing events—creating a record preserved as chronological segments. In addition, as the quartz grows, it frequently traps microscopic droplets of fluid from which the crystal precipitated. Corralled into segments across a quartz bridge, the droplets serve as a record within a record.

"Those are the fluid inclusions, little time capsules for the formation of the cement," said Research Scientist András Fall, a fluid inclusion expert in the FRAC group.

Fluid inclusion analysis can reveal the type of fluid inside a fracture, and the temperature, pressure and formation history of the crystal that precipitated from it. This type of analysis was the key part of a 2010 study led by Steven Becker, who conducted the research in the FRAC group while he was a postdoctoral fellow at the bureau. It presented evidence for fractures forming over tens of millions of years—conflicting with the prevailing thought that they formed more or less instantly.

The study was conducted on the same bridge structure in the East Texas core sample examined by Laubach and Lander in 2004, and it found that the fateful quartz bridge formed over 48 million years—an interval lasting nearly as long as the entire Cambrian Period—and growing at a rate of 16 to 23 microns every million years.

The findings were not totally unexpected though. Years earlier, Olson had built a physics-based model that calculated some fracture patterns forming over tens of millions of years. At the time, the long formation time took a backseat to the patterns themselves. But the fluid inclusion findings showed that the model might have been on to something.

"I thought it was pretty cool," Olson said. "I had been doing it in a purely physical space, using fracture mechanics principles it looked like it took tens of millions of years for the fractures to form. And then the fluid inclusion work totally independently came up with the observations."

Whereas the quartz bridge took millions of years to form, FRAC's hydrothermal lab is studying the conditions that control that growth all while staying in the same geological epoch; most structures take just a few days to grow.

Fall runs the lab, which was founded to experiment with the models for quartz growth first described by Lander and Laubach. The general process involves placing pre-fractured quartz and fluids in heated pressure vessels meant to simulate the depths of the subsurface. By studying the crystal structures and associated fluid inclusions that form inside fractures under these controlled settings, Fall is learning more about the conditions that steer their formation in the field.

From crystal linings, to segmented bridges, to the fluid inclusions inside of them, there's an array of features that appear together inside of fracture deposits. The members of the FRAC group are pioneers in using a powerful tool to get a closer look: scanning electron microscopy combined with cathodoluminescence.

Scanning electron microscopes, or SEMs, capture high-resolution images by bombarding a sample with an electron beam. But the attributes that are visible in the final image analyzed by scientists depend on the type of detectors that are attached to the microscope. The cathodoluminescence (CL) detector turns the backsplash of photons emitted by rock samples into glowing, high-definition mosaics. Here, fractures with crystal coatings go from looking more or less the same to no two looking alike.

"SEM-CL reveals the textures that you wouldn't be able to see with any other imaging method," said Sara Elliott, a research scientist associate in charge of the group's SEM microstructural imaging.

Research Scientist Estibalitz Ukar is leading the way in applying the technology to fractures coated with carbonate cement deposits—which make up the majority of minerals found inside fractures outside quartz-rich sandstone, but have hardly been studied using high-resolution techniques due to their tendency to phosphoresce and create smudgy images under standard SEM-CL conditions.

When Ukar was hired in 2013, she used her startup funds to purchase the SEM that is now in use. She credits the amazing array of clear, crisp CL images of carbonate structures that the lab has been able to collect with being selective about the right scope—a model that could operate at low energy and still create a lot of luminescence—and the extensive array of samples the lab has on hand to study. By perusing the "FRAC Library," she found a number of different textures and structures present in carbonate coatings.

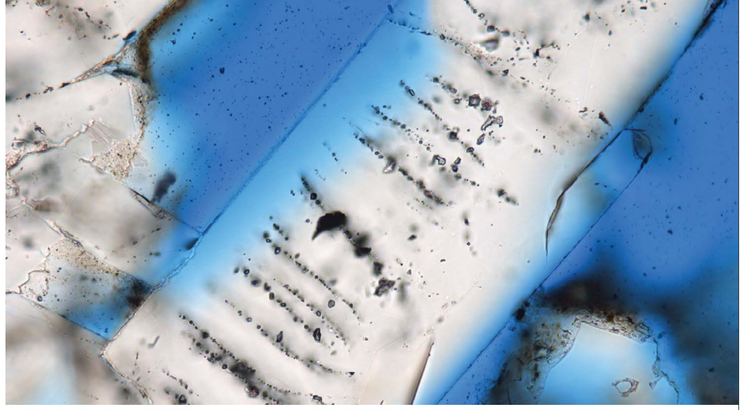
"It was a hope, but really more of a surprise, to find such beautiful examples [of carbonate] showing the same types of textures we had already seen in quartz," she said.

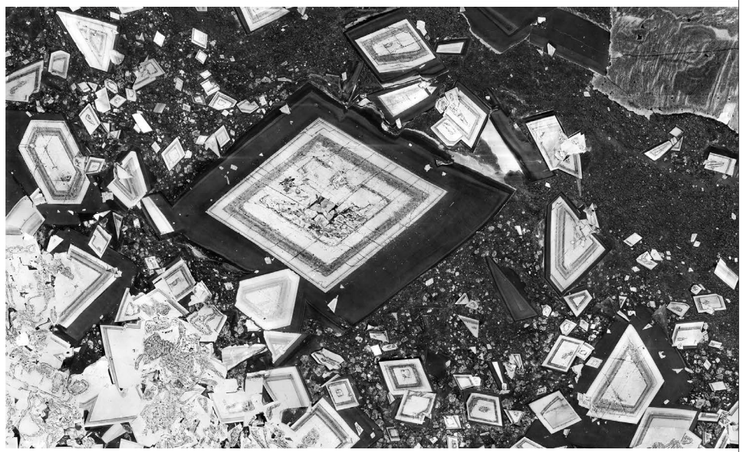
In 2016, Ukar published a paper describing different carbonate cement features she observed inside of fractures in an array of samples from all over the world. So far, they appear to have much in common with the quartz deposits that have been the primary focus at FRAC for so long, even spanning fractures in the form of crystal bridges. Research on quartz coatings is relevant to the oil and gas industry since it is the mineral that is most frequently present in fractures in sandstone. But Ukar said that carbonate cements are far more abundant, encompassing all rock types including carbonates, shale, sandstone and basement (crystalline) rock. In order to understand more about fractures in all types of rocks and settings, carbonate cements need to be just as much a part of the conversation.

"Quartz is the most abundant mineral in fractures within sandstones that are quartz rich, but in everything else it's carbonate," she said.

Analyzing the life history of individual fractures is just part of the story. The next step is to use SEM-CL and fluid inclusion analysis to determine the development and timing of multiple fractures within a set.

Jackson School doctoral student Stephanie Forstner is conducting research that applies these techniques, as well as burial history modeling, to investigate the geologic history of the highly fractured Cambrian Flathead





BLUE: ANDRÁS FALL. GREY: SARA ELLIOTT.

sandstone exposed throughout the Teton Range in western Wyoming. Forstner's fractures are exposed at the Earth's surface in outcrops. But most were formed underground. By distinguishing how and when they formed, her work is helping illuminate the timescales and environments in which fractures create underground networks.

"My goal is to collect evidence in the field that ultimately provides insight into how fractures develop underground," she said. "The Flathead is an ideal unit to study fracture development because it hosts multiple generations of subsurface-originating fractures that developed over a span of about 60 million years."

FRAC in Shale

A focus on structural diagenesis has prioritized natural fracture research in the FRAC group. Induced fractures—such as those made during hydraulic fracturing operations—don't have crystal coatings to unpack.

Nevertheless, a growing interest in how induced fractures interact with natural ones has put FRAC researchers at the forefront of core analysis at the DOE-sponsored Hydraulic Fracturing Test Site. The goal of Gale's research at the test site is to build up a public data repository on hydraulic fractures and their behavior in the subsurface. Since 2016, Gale and Elliott have been part of the team analyzing cores pulled from the Permian Basin, including samples from the Wolfcamp Shale in the Midland and Delaware basins.

The project results have attracted a huge amount of industry interest. In 2018, the American Association of Petroleum Geologists, the Society of Exploration Geophysicists and the Society of Petroleum Engineers held a special session in Houston at their joint annual conference on Unconventional Resource Technology dedicated to discussing unconventional hydrocarbons in which Gale and Elliott presented the preliminary results on the test site cores.

"There was standing room only in really big rooms," Gale said.

Interpreting the cores is an ongoing effort, Gale said. But she and Elliott have already produced two papers characterizing core pulled from the different plays. Some interesting fracture features observed in both plays include hydraulic fractures appearing in closely packed pairs and triplets, a pattern that suggests bifurcation; proppant packs and patches; and, surprisingly, little induced fracturing appearing parallel with the rock layers.

Many of the natural fractures in the cores are sealed with calcite crystals, making them easy to distinguish from induced fractures. In contrast, fracture patterns made by drilling and injection of hydraulic fluid look very much the same. Gale said a big question is whether the hydraulic fracturing process is "reactivating" natural fractures—opening them up so they can serve as a passageway for hydrocarbons. But pinning down the opening of these natural fractures by hydraulic fracturing operations, let alone distinguishing between the role of drilling versus fluid injection in causing the opening, is something that remains out of grasp for now.

"I've been cautious of over-interpreting," Gale said. "People want to grab the observations and run with them. I would say there's a lot of uncertainty."

Naked Fractures

As the cores from the Hydraulic Fracturing Test Site show, overcoming equifinality is an especially daunting challenge for fractures without crystal coatings. The patterns remain "simple," and there's nothing inside to interrogate for more clues.

Although unable to reconstruct specific fracture history, mechanical and statistical research has made progress in understanding how fractures form in response to stress and interpreting fracture arrangement. This type of work is part of the FRAC group too. Olson's research centers on building physics-based models of fracture pattern formation and fracture interaction. And much of Marrett's work focused on how, in certain instances, fracture patterns in nature exhibited fractal behavior, with patterns maintaining a consistent arrangement over scales of magnitude—from microfractures to macro ones.

The newest member of FRAC, Michael Pyrcz, an associate professor in the Cockrell School and the Jackson School, has built a career on applying computational and statistical tools to problems in the geosciences. Before joining UT in 2017, he spent 13 years at Chevron building software for a host of geoscience environments—including fracture modeling and forecasting.

Now part of the FRAC group, he thinks that statistics and computing tools could mine complexity that exists in so-called simple patterns. He and his students use spatial data analytics and machine learning as new lenses to explore and model the subsurface.

"There's no reason to bring in geostats if you can model it deterministically," Pyrcz said. "But we have to augment our physics-based workflows with statistical, data-driven approaches to characterize and manage subsurface uncertainty."

Fracture Forward

In August 2019, Laubach and others published a paper in the *Reviews of Geophysics* that gave an overview of how chemistry influences fracture pattern development, insights that structural diagenesis has enabled. The paper came out of a 2016 fracture workshop sponsored by the DOE, but it took so long to compile and write because searching the literature kept uncovering a wealth of research relevant to fracture science—from reactive transport modeling to studies in the engineering world.

The paper ends with a list of nine points of actions for fracture research in the future. But the heart of enabling these breakthroughs will involve getting more people in the structural diagenesis mindset, Laubach said.

"Changing perspective often is the most important thing that you can do in addressing a difficult problem," he said.

Another important part is being adaptable. As part of the next generation of FRAC researchers, Fall and Ukar envision expanding the consortia's membership while still serving as a critical resource for the oil and gas companies, which make up the majority of their members.

And there's plenty of room to expand. Some of the biggest challenges facing society intersect with subsurface fractures. As sea levels rise, coastal aquifers are becoming vulnerable to seawater seeping up through fractures, while fighting climate change with carbon capture and storage means ensuring that fractures won't serve as inadvertent escape hatches for greenhouse gas injected into geologic formations. Ukar and Fall see these as potential growth areas for future research.

Another area for research is geothermal and hydrothermal energy, an area where FRAC's ongoing work puts it in an especially good position.

Senior Research Scientist Peter Eichhubl and postdoctoral researcher Owen Callahan are investigating how microfractures affect rock strength in hydrothermal environments, with the researchers investigating field samples from the Dixie Valley-Stillwater Fault Zone of Nevada. The same carbonate minerals that Ukar has been studying for years readily precipitate in geothermal settings, while Fall's hydrothermal laboratory offers a ready-made setup for simulating the fluid-rock interactions in real time. And that's not to mention the expertise offered by the bureau's new associate director, Ken Wisian, who has experience applying geothermal research in industry settings via UT's Geothermal Entrepreneurship Organization.

"The group has all these years of combined expertise," Ukar said. "We're in a good spot to apply our knowledge to addressing some of the biggest geological challenges of this century."

OPPOSITE PAGE, TOP: QUARTZ CEMENT BRIDGE WITH FLUID INCLUSION ASSEMBLAGES CONTAINING HYDROCARBON GAS INCLUSIONS. SAMPLE FROM THE PICEANCE BASIN, COLORADO.
OPPOSITE PAGE, BOTTOM: ZONED DOLOMITE RHOMBOHEDRA FILLING A SOLUTION BRECCIA CAVITY FROM THE KNOX FORMATION, CENTRAL TENNESSEE. IMAGE TAKEN UNDER PANCHROMATIC SEM-CL.

PRESSURE RISING

BY CONSTANTINO PANAGOPULOS

HYDRATES PROJECT ENTERS FINAL PHASE BEFORE GULF OF MEXICO PRESSURE CORING TEST

It's mid-March on the Texas prairie outside the city of Cameron.

Peter Flemings, a professor at the Jackson School of Geosciences, watches the rig hands lower the prototype sensor into the well. The counter still reads 1,000 feet from bottom when the thick steel cable suddenly goes slack. Moments later, a dull clang echoes across the rig floor.

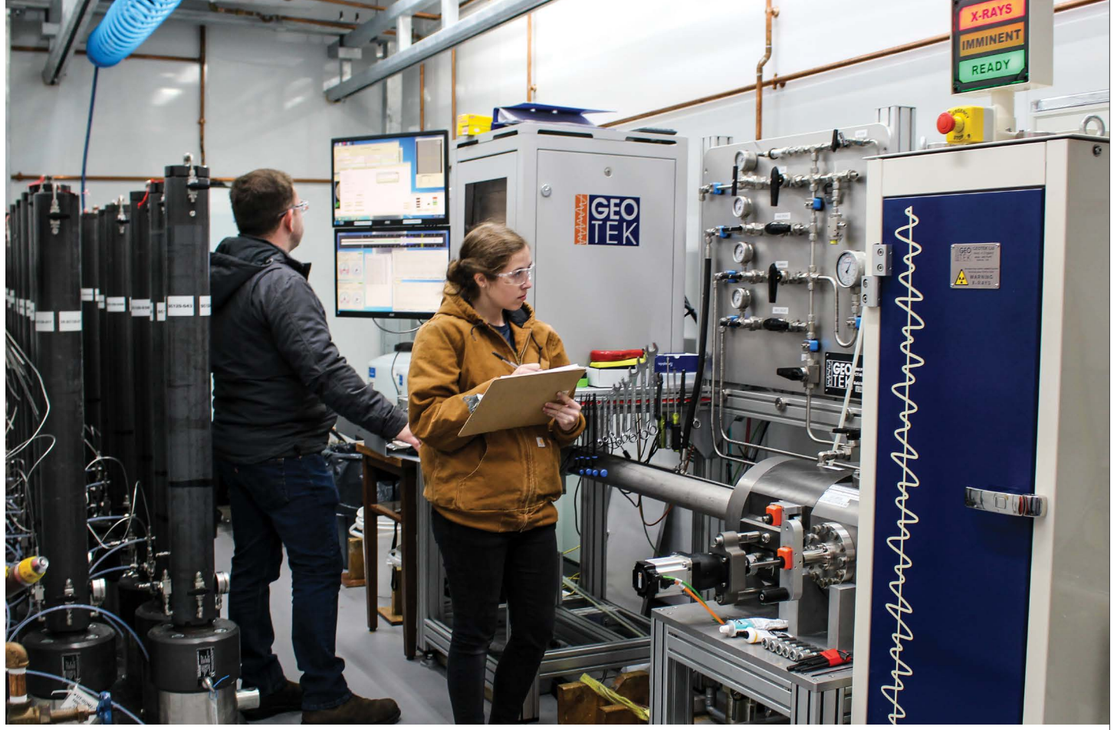
Shaking his head, Flemings turns to Jackson School graduate student Zach Murphy, who is taking notes nearby.

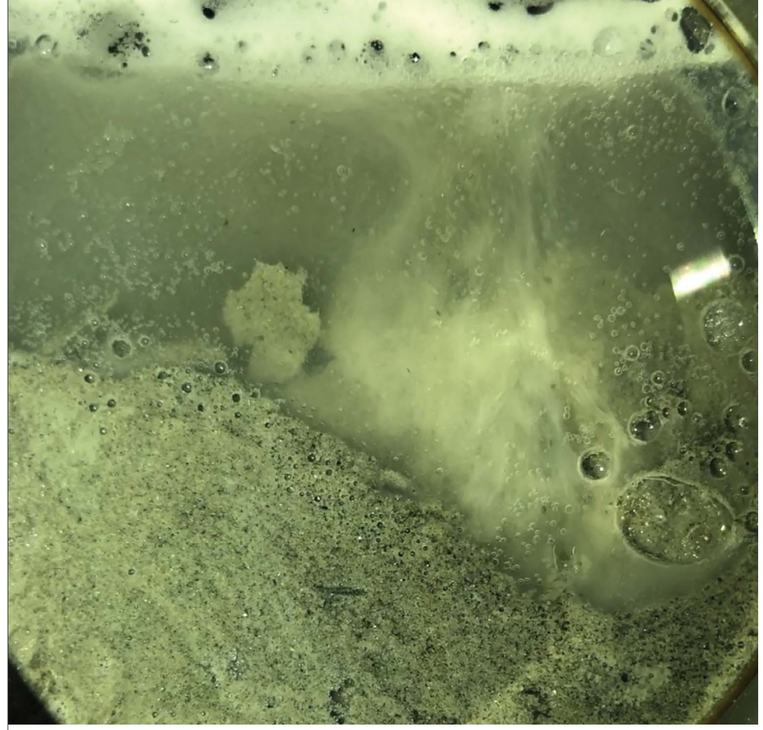
"You can just put train wreck," Flemings said.

Ominous words, but if Flemings has learned one thing, it's that engineering development is a slow and brutal process. With each failure, however, the team of scientists and engineers is one step closer to achieving a goal few have even attempted — reliably capturing cores of methane hydrate from beneath the seafloor and returning them to the surface at the high pressure and low temperature necessary to keep the substance stable. It's all part of a $100 million Department of Energy-funded project led by The University of Texas at Austin to study methane hydrate as a potential energy source.

OPPOSITE PAGE: A HELICOPTER LANDING ON THE HELIX Q4000 DEEPWATER WELL INTERVENTION VESSEL DURING THE 2017 CORING MISSION. CREDIT: PETER FLEMINGS.

LEFT: JACKSON SCHOOL GRADUATE STUDENT ZACH MURPHY LOGGING CORE DURING CORING LAND TESTS NEAR CAMERON, TEXAS. CREDIT: AARON PRICE.





During this field test, the failures have helped the team pinpoint the source of a perplexing issue with the coring tool during the Jackson School's 2017 mission that retrieved cores from beneath the Gulf of Mexico.

"We verified the latest round of design changes and revealed a problem we'd struggled with since 2017," said project co-investigator Steve Phillips, a research associate who recently moved from the Jackson School to the U.S. Geological Survey. "With the problem isolated, we can now engineer a solution."

The test showed that the tool was getting stuck like a jammed drawer, which prevented it from sliding freely. Working with engineering firm Geotek at another facility in Salt Lake City, the team has since designed and engineered a solution that has resolved the problem.

That's good news and bodes well for the team as they're preparing to return to the Gulf of Mexico for a much larger coring mission in 2022.

The mission's goal is to drill more than half a mile into the seafloor and bring back sealed cores rich in methane hydrates—an energy-dense material that forms readily along continental coastlines and beneath permafrost but is unstable on the Earth's surface.

To prepare, Flemings and a team of Jackson School researchers oversaw the technology test at a Schlumberger-operated rig near Cameron.

The team also included UT graduate students, technical staffers and postdoctoral researchers who learned firsthand how the technology works—experience that will be invaluable when they join the deepwater expedition in 2022.

Flemings, who led the 2017 mission, knows that pressure coring is complicated, and his team will need all the help they can get.

"Recovering pressurized cores means a thousand things have to move in concert in a 4.5-inch diameter muddy hole, at enormous pressure," he said. "Every part of this mouse trap is a potential mode of failure."

At the heart of the "mouse trap" is the Pressure Coring Tool with Ball, a sophisticated combination of devices designed to cut and seal sediment cores under pressure.

Although the tool saw moderate success in 2017, the new tests revealed that during coring, tiny rock chips could clog up the mechanism that seals the core. Despite rigorous lab tests, the problem emerged only when the tool was actually cutting into rock.

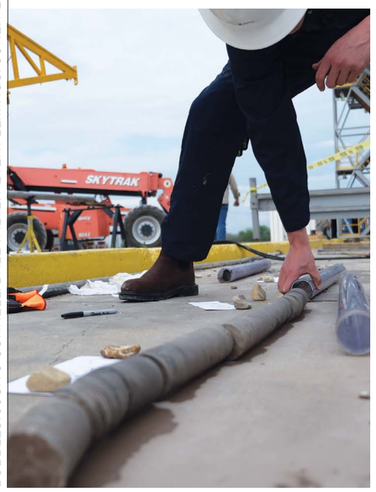
Finding and squashing bugs in the system is exactly why the $1.5 million land tests are so important.

"If we solve this final problem, one of our greatest contributions to the community will be to have helped develop a tool that's rugged, efficient and fit for the field," Flemings said.

With the land test now behind them, the team has turned to experiments underway at the Jackson School's Pressure Core Center, the only university-based facility equipped to safely store and study pressurized methane hydrate cores. Projects include a student-led experiment that will, for the first time, replicate production conditions in the lab, and an experiment simulating injecting carbon dioxide mixtures directly into hydrate reservoirs. Both experiments could play a vital role in turning methane hydrate into a future fuel while also storing greenhouse gases underground.

The group's scientific findings from the first expedition were published in September 2020 in a special bulletin from the American Association of Petroleum Geologists. A second special bulletin is planned for the future.

With two years to go until the next marine expedition, the group still has work to do. At the top of the to-do list is the drilling permit, which will require coordination and effort at all levels of UT's administration, including the president's office. The team also needs to secure a drilling vessel and hire the personnel required to run a two-month deepwater drilling operation. Fortunately, one of the biggest hurdles, the expedition's science plan, is now complete.



Unlike the 2017 expedition, which brought back 20 pressurized cores from a single hydrate deposit in the northern Gulf of Mexico, the plan for the second expedition calls for at least 50 cores from two reservoir types, totaling 500 feet of carefully sealed methane hydrate cores. Studying different types of reservoirs will give a much clearer picture of how the deposits form and how they could be put to use.

The researchers are also planning on learning more about the methane-producing microbes that feed the reservoirs by taking hundreds of feet of conventional samples, and by deploying a newly developed instrument that measures temperature and pressure within the sandy reservoirs where methane hydrates accumulate, something never done before.

The data will answer fundamental questions about the source of the methane and how it moves through the Earth's subsurface, squeezing through tiny gaps and fractures in the rock to form hydrate reservoirs.

Phillips said that with the science plan set, the team feels well prepared to tackle the final phase before the expedition. He added that being in the front seat of pioneering potentially world-changing science is a really great place to be.

"The things we'll be doing I've wanted to do for years," he said. "Honestly, I can't wait to get out there."

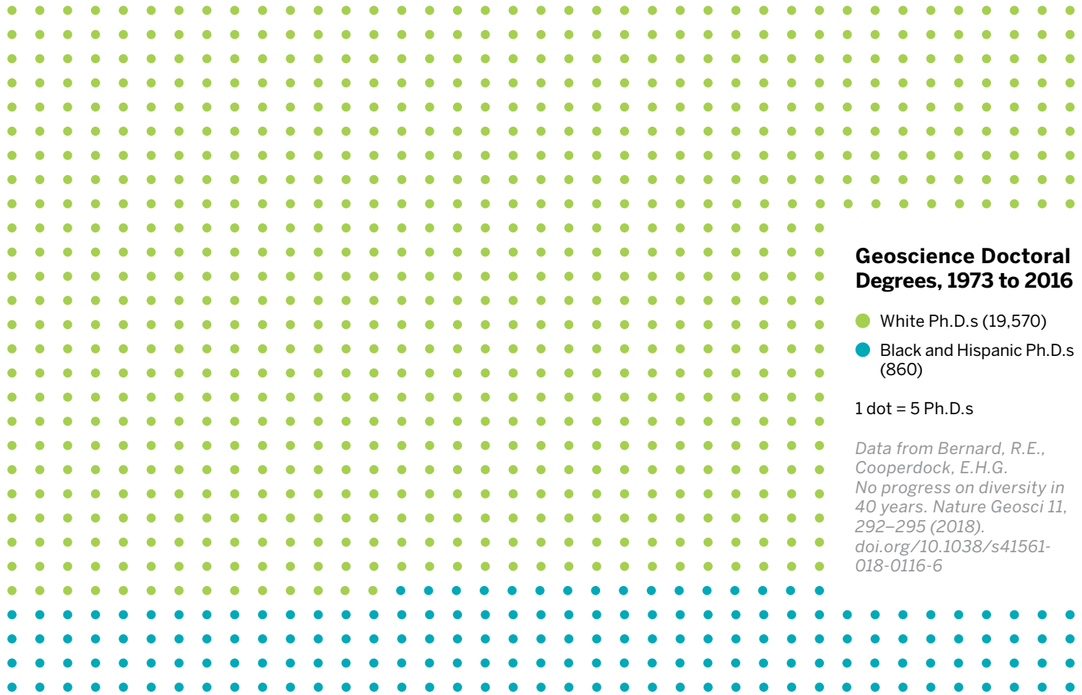
PHOTO: JACKSON SCHOOL.

BUBBLES: JOSH O'CONNELL. BALL VALVE: PETER FLEMINGS. CORE: PETER FLEMINGS.

OPPOSITE PAGE: LAB MANAGER JOSH O'CONNELL AND STUDENT RESEARCH ASSISTANT ADDISON SAVAGE MONITOR EQUIPMENT IN THE UT PRESSURE CORE CENTER. ON THE LEFT ARE ROWS OF PRESSURIZED CORES RETRIEVED FROM THE GULF OF MEXICO IN 2017.

ABOVE, LEFT: METHANE BUBBLES FORM AS A FIELD SAMPLE OF GAS HYDRATE COLLECTED DURING THE 2017 CORING MISSION IS ALLOWED TO DEPRESSURIZE.
ABOVE, RIGHT: THE BALL VALVE OF THE PRESSURE CORING TOOL BEING USED TO RETRIEVE SAMPLES OF METHANE HYDRATE.
LEFT: A MEMBER OF THE DRILLING TEAM LAYS OUT CORES DURING THE LAND TEST OF THE TECHNOLOGY THAT WILL BE USED ON THE NEXT MISSION TO RETRIEVE SAMPLES OF METHANE HYDRATES FROM BENEATH THE SEAFLOOR OF THE GULF OF MEXICO.

INCREASING DIVERSITY IN GEOSCIENCES



THE GEOSCIENCES ARE AMONG THE LEAST DIVERSE STEM FIELDS. AT EVERY LEVEL, THE JACKSON SCHOOL OF GEOSCIENCES IS WORKING TO CHANGE THAT.

BY MONICA KORTSHA

There's a good chance you would recognize Jackson School of Geosciences alumnus Tim Shin even if you've never met him. That's because Shin's face is on the cover of an undergraduate brochure that the school used for years to recruit students.

On the brochure, Shin is smiling as he looks up from a stack of papers. His undergraduate adviser, Department of Geological Sciences Associate Professor Elizabeth Catlos, is pictured beside him, leaning over his shoulder. With his face front and center on that brochure, Shin represents the school.

But the truth is that he is far from representative of the school. That's because Shin is Black, and, put simply, most people in the Jackson School—and in the geosciences as a whole—are white.

When Shin started his master's program at the Jackson School, he was the only Black graduate student. In fall 2020, some 10 years after he graduated, the count has increased by just a single student. Shin says he has many positive memories of his time at the Jackson School, but like other minority students who have come forward in recent months, those memories are peppered with stories that gave Shin the impression he was an outsider, or, even worse, did not belong.

There were comments from professors like "you're surprisingly well spoken" or "I guess it's better to be lucky than smart." There was the simple fact that not a single faculty member looked like him. There was the realization that most of his white classmates grew up camping—a seemingly foundational skill in a school that stresses field work, and a skill that Shin had virtually no experience with.

Now years into a successful geosciences career, Shin has seen these types of issues throughout the industry. He's certain most are not intentional.

But he says he can't help but think that his alma mater, with its lofty position in the geosciences, should be leading the charge for equity and inclusion.

"The Jackson School is doing a lot better and has done a lot better than many similar institutions, but it's got a lot left to do," Shin said.

Many alumni and those within the school agree.

The Jackson School has been working hard for years to address the lack of diversity within the school and the geosciences as a whole, and to make the environment more welcoming to students from underrepresented groups. Some of the efforts are well known, others are not.

You may have heard of **GeoFORCE**, the Jackson School's award-winning program that teaches geosciences to high school students from underserved communities in Houston and southwest Texas. There are also a number of other programs that support students as they enter college, go on to graduate school, and beyond.

Still, the truth is that all these efforts have moved the needle very little. Much of the progress has been in increasing gender diversity; women now make up 50% of the school's assistant professors and 43% of all students.

But in the spring of 2020, the latest term for which there is complete demographics information, the Jackson School student body contained one Black graduate student and no Black undergraduates. The Hispanic representation was 7% for graduates (exclusive of international students) and 14% for undergraduates, significantly below the almost 53% that make up the overall population in Texas public schools.

There has been a distinct uptick in interest of the school's diversity efforts since the Black Lives Matter protests in the wake of the killing of George Floyd. Alumni and graduate student groups have sent messages to Jackson School leadership. And more than two dozen members of the Jackson School community—students, faculty members and staff members—came together for a #ShutDownSTEM event on June 10 to reflect on racism in the geosciences and discuss solutions for improving diversity, particularly for Black students, in the Jackson School.

At the same time, the Jackson School, led by Dean Claudia Mora, has continued the process of evaluating its diversity programs and instituting more training for faculty and staff members. The school is also redoubling its effort to spread the word about diversity and inclusion efforts at the school and the actions it is taking to develop and support geoscientists from underrepresented groups at every level.

The problem is longstanding and entrenched. But the fact that people throughout the Jackson School community have expressed interest in being part of the conversation now is a big step to doctoral student Kiara Gomez, who has been a member of the Jackson School's diversity and inclusion committee since 2016 and recently co-founded a Jackson School chapter of **GeoLatinas**, an international organization for Latinas in geosciences.

"It can be hard for people [who aren't from underrepresented groups] to understand, and for things to feel a bit overwhelming

TIM SHIN IN THE FIELD. SHIN EARNED A BACHELOR'S AND MASTER'S DEGREE FROM THE JACKSON SCHOOL AND NOW WORKS IN THE ENERGY INDUSTRY.

PHOTO: TIM SHIN.

if they have been hanging out on the sidelines," she said. "Talking more about diversity is a central thing. I don't want it to stop."

It's the type of energy, said Mora, which can help move the needle as long as it's ongoing, consistent and constructive.

"The Jackson School has been doing things, and is doing things, and will do things [to address diversity and inclusion]," Mora said. "We have a lot of interest and we can take advantage of this time to improve things markedly."

Demographics

At every degree level, the geosciences are among the least racially diverse of all the STEM disciplines, according to data on degrees earned at U.S. universities collected by the National Science Foundation.

In 2016, the most recent year for which data is available, only 2.2% of Earth, atmospheric, and ocean sciences bachelor's degrees—a total of 155 degrees—went to Black students, and that percentage has remained flat over the previous 10 years. In comparison, Hispanic students earned 9.1% of Earth, atmospheric, and ocean sciences bachelors in 2016, an increase from 3.7% earned in 2006. The trends are similar for master's degrees. Black students never break 2.6%; Hispanic students went from 3.6% in 2006 to 6.3% in 2016.

At the level of the doctoral degree—the de facto requirement for academic positions in geosciences—the percentage of underrepresented minorities earning degrees has hardly budged in 40 years. And for Black geoscientists, it hasn't changed at all.

Jackson School alumni Rachel Bernard, who is Black, and Emily Cooperdock compiled the Ph.D. data for a 2018 study in *Nature Geosciences*. They found that in 2016, Black geoscientists earned 1% of Ph.D.s—the same percentage earned by all Black geoscientists from 1973 to 2016. And while the number of Hispanic geoscientists earning Ph.D.s has increased—in 2016 they earned 5% of degrees, up from 2.8% over the entire 40-year period—that increase reflects a growing Hispanic population in the United States in general.

When put in terms of total doctoral degrees over the past 40 years, the chasm between Black and Hispanic geoscientists and white geoscientists is stark: 860 vs. 19,570.

At the Jackson School, the diversity of both staff and non-international students reflects these larger trends.

Black students have made up about 2% of the undergraduate student body on average during the past decade. Hispanic students made up 16.2% of undergraduates on average over the same period—a value that's lower than the 21.7% of Hispanic students that made up UT's student population in 2019.

For graduate students, the number of Black students has never reached above two at any given time during the past decade, while Hispanic students make up 6.2% of graduate students on average.

The Jackson School faculty similarly lacks diversity, with 14% of faculty members of Asian descent, but only one faculty member from underrepresented groups, Dean Mora, who is Latina.

The absence of educators who are Black or Hispanic means that students from these groups have to look elsewhere for role models whose presence demonstrates that a career in geosciences is possible for them. Shin and fellow alumnus Stanley Stackhouse said it was conferences that first gave them a glimpse of what might be possible for them as Black geoscientists.

"Once you go to some of the national conventions, you really are exposed to a more diverse community, including Black geoscientists who are actually in positions that you're trying to achieve," Stackhouse said.

For Shin, meeting Black faculty members and others who held high positions in the geosciences as an undergraduate student at his first Geological Society of America meeting was eye opening.

"It was huge for me," Shin said. "A huge boost."

Bernard, now a visiting assistant professor at Amherst College in Massachusetts, is experiencing this from the other side.

"A lot of students have been approaching me," Bernard said. "Just by being there, I've had several—all [white] women and women of color—approach me and just want to talk. And they've told me it was because I was the only woman of color in the department."

Inspiring Future Geoscientists

Professors and professionals can have a big influence on developing the next generation. But the fact remains that geoscientists from underrepresented groups make up a small community. Bernard used the NSF data to determine where she ranked among other Black women who had earned Ph.D.s in geosciences during the past 40 years. She found that as a 2018 graduate, she is about the 30th Black woman to earn a Ph.D. in the earth sciences.

As that number illustrates, there is no way to improve the diversity of the geosciences community without growing the diversity of geosciences students who can then go on to careers in academia or industry, and help serve as role models to others along the way.

This approach is often characterized as increasing the flow into a "pipeline." But research shows that the pipeline has a number of leaky points, places where students exit geosciences.

One strategy is not enough to make meaningful change. That's why the Jackson School has a number of different programs that seek to support students from underrepresented groups at every step of the way, said Samuel Moore, the Jackson School's director of outreach and diversity.

"We're working on having allies here for the students of color," he said.

The main focus remains at the start of the pipeline. Outreach programs such as **GeoFORCE**, **Geoscience Ambassadors** and **OnRamps** target students who have little to no geosciences education. Their goal is not just to spread awareness about the geosciences—but to help students envision themselves as geoscientists.

Piquing Interest

Since 2005, GeoFORCE has been introducing Texas high school students from underserved communities to the geosciences by taking them on field experiences, called academies, each summer with all travel expenses paid.

Modeled after a similar program at Fort Valley State University, a historically Black college in Georgia, GeoFORCE accepts about 84 eighth grade students into the program each year, with about 60% of students identifying as Hispanic and about 15% as Black. The students then spend about a week each summer for the next four years learning about geosciences in the field. The program also provides support to students as they apply to college and graduate school.

Program coordinator Dana Thomas guides GeoFORCE students through the transition from high school to college through the **GeoSTEM Bridge Program**. She said that year after year she receives feedback from students about the transformative effects of GeoFORCE. She has heard from students who directly credit the program with their decision to study STEM, and from first-generation college students who cite the support and encouragement of GeoFORCE as essential to their college success.

So far, 100% of GeoFORCE participants have graduated from high school, with about 90% making it through at least their second year in college, and 44% of currently enrolled students studying a STEM field. The program has also received the highest honor for STEM education from the U.S. government. In 2015, Moore and Doug Ratcliff, the founder and former director of the program, travelled to Washington, D.C., to accept the Presidential Award for Excellence in Science, Mathematics and Engineering Mentoring, meeting with President Barack Obama during the visit.

As of August 2019, GeoFORCE alumni had earned 65 bachelor's degrees and 11 master's degrees in geoscience, with about 60% of those degrees earned by underrepresented minorities. However, in comparison to the 550 degrees earned by GeoFORCE alumni thus far, those in geosciences make up only about 14%.

GeoFORCE is working to boost those numbers in part by revamping the 12th grade field academy experience based on results from a four-year NSF-sponsored study led by Kathy Ellins, the program director for geoscience education research. Starting in 2018, the academies have shifted from lectures by a single "sage on a stage," as Ellins puts it, to an emphasis on challenge-based activities led by a diverse instructional team that includes graduate and undergraduate students from similar racial, ethnic and cultural backgrounds as the students.

Leah Turner, who became the program director for GeoFORCE in December 2018, said that another aspect of revamping the curriculum involves learning more about GeoFORCE students' values, goals and perceptions of success—and then revising the curriculum to more intentionally connect geosciences to these points.

She also plans on increasing student exposure to geoscience careers by connecting students with professional mentors who can talk about what their day-to-day lives as geoscientists are like. The goal is to make a career in geosciences stand out among other career tracks that students encounter more frequently.

"Some students are like, 'This is great, but what does this life look like?'" Turner said. "So our professional mentors on these field experiences have to be as powerful as the teachers they see every day, as the nurses they visit ... they have to demystify some of the geoscience-related careers."

They also have to address geosciences' reputation as a field for outdoorsy, white men—a character that Shin jokingly calls the "geo bro"—which is something that can give pause to potential students who don't fit that mold.

A program led by Jackson School Professor Julia Clarke that emphasizes students from diverse backgrounds is directly countering that stereotype. Founded in 2018, the Geoscience Ambassadors gives students a platform to tell the story of how they found the geosciences and to research community perspectives. Students then use this work to reach others in their community.

"It enables students to connect with influencers in a community and come up with diverse approaches to sharing their path to the geosciences and empowers them to design new engagement opportunities in partnership with these communities," Clarke said.

The goal is for each student to create inroads to the geosciences by sharing their "pathway stories" at community events.

To date, more than 1,500 participants have been engaged in ambassador-designed programs in a wide variety of contexts, including schools, churches, homes, military and professional networks and social groups. However, Clarke said that the survival of the program depends on securing a long-term funding source.

A seed grant from the Howard Hughes Medical Institute got the program started. But keeping it going will require additional funds.

In the meantime, the stories of the Geoscience Ambassadors are being mobilized for broader impact as a collection of short, autobiographical videos available to teachers and other influencers via the Geoscience Ambassadors' website. (Watch them at: ***www.geoscienceambassadors.net***)

The Geoscience Ambassadors is a relatively small program. But for the past six years, the Jackson School has been bringing geosciences to thousands of high school students across Texas by partnering with high school teachers to teach OnRamps Earth Wind and Fire: Introduction to Geoscience.

The course is part of UT's OnRamps program, which provides curriculum and teacher training in 13 college-level courses. This spring, the introductory UT geoscience course was taught to more than 1,200 high school students—mostly seniors but also some juniors—in about 70 schools across Texas. Most of the students who took the course belong to an underrepresented group; 57% identify as Hispanic and 13% as Black—which nearly mirrors the state's overall public school student population.

"For most students, this is the first and only geosciences and environmental class they get in high school," said Associate Professor Joel Johnson, who teaches GEO 302E, the undergraduate

OPPOSITE PAGE, TOP: SAMUEL MOORE, THE JACKSON SCHOOL'S DIRECTOR OF OUTREACH AND DIVERSITY, MEETS WITH TWO EDGE PARTICIPANTS IN 2019.
OPPOSITE PAGE, BOTTOM: RACHEL BERNARD EARNED HER DOCTORAL DEGREE AT THE JACKSON SCHOOL IN 2018. SHE IS NOW A VISITING ASSISTANT PROFESSOR OF GEOLOGY AT AMHERST COLLEGE.

ABOVE: GEOFORCE STUDENTS DURING A SUMMER ACADEMY FIELD TRIP TO INKS LAKE STATE PARK IN 2012. LEFT TO RIGHT: AHAWA GHEBRELUL, MEMPHIS EDWARDS AND DAJANIECE "DJ" GUIDRY.

MEETING: OFFICE OF BROADER IMPACTS OF GEOSCIENCE RESEARCH. BERNARD: RACHEL BERNARD.

FIELD TRIP: GEOFORCE.

course that the OnRamps class is modeled after. "That opens the door, or potentially does, to studying it in college. You study what you know, and this class builds a familiarity with earth sciences."

In addition to teaching geosciences, the course provides a preview of the college experience. Students upload their assignments online so UT graders can review them. The students can also opt to have their grade counted as college credit.

Johnson and Alison Mote, the course manager and a Jackson School alumna, are working to further that college connection by finding opportunities for Jackson School undergraduates to talk to high school classes.

"We reach an audience that is far more diverse than the geosciences community, and making the connections more explicit is part of our goal," Johnson said.

Overcoming Barriers

Helping students from underrepresented groups see themselves as geoscientists is an important start. But students often run into barriers when entering the college system—from not being able to afford tuition, to weak science and math skills, to not knowing how to navigate a complex academic system.

The GeoSTEM Bridge Program helps 12th grade students who completed the GeoFORCE program overcome these barriers by supporting them as they navigate the transition from high school to college. That includes help finding scholarships, completing applications and preparing for rigorous college courses with a Math and Science Institute taught by UT professors, said Thomas.

In 2020, GeoFORCE and the Office of Broader Impacts in Geosciences Research added a new program that focuses on supporting undergraduate and recently graduated students. Called **GeoVISION**, the program is a research traineeship that connects GeoFORCE alumni and other students from underrepresented groups with Jackson School researchers. This year, 23 students took part, with about half working one-on-one with Jackson School scientists on personal research projects. All GeoVISION students took part in virtual training sessions and skill-building sessions, with research scientist Gail Christeson teaching the basics of the programming language Python, Associate Professor Michael Pyrcz teaching geostatistics, and Assistant Professor Timothy Goudge teaching remote sensing.

A primary goal of the GeoVISION program is to introduce GeoFORCE alumni to the research environment at the Jackson School and encourage them to pursue their research by earning a graduate degree from the school. Two other programs do the same but reach into a broader pool of students: The **EDGE (Enhancing Diversity in Graduate Geosciences Education)** program and a student research partnership with Fort Valley State University, the same historically Black college that runs the program that GeoFORCE was modeled after. All of these programs help build connections between participants so that students can belong to a group even before they begin their degree programs.

The EDGE program was started in 2018 as a means to introduce prospective graduate students from underrepresented groups to the Jackson School community. The two-day program covers the costs of travel, lodging and meals. Students meet with faculty members and research scientists, tour facilities and attend information sessions about the graduate program. The Jackson School's two current Black graduate students were recruited through EDGE.

The Fort Valley State research collaboration, a program founded in 2013, lets students experience research at the Jackson School firsthand. The program brings two undergraduate students from Fort Valley State to the Jackson School each summer to take part in research opportunities across the school's three research units and the Texas Advanced Computing Center.

The program grew from a dual-degree partnership between UT and Fort Valley State that ran from 2005 to 2015. The program enabled Fort Valley State students to earn a STEM degree from Fort Valley State in three years and then transfer to the Jackson School or Cockrell School of Engineering to earn a geosciences or engineering degree in two. The degree program gradually shifted to research collaboration as a means to manage costs while still getting undergraduate students involved with geosciences research and potentially attracting them to graduate school, Moore said.

During the first 10 years of the dual-degree program, six students earned bachelor's degrees from the Jackson School—including Stackhouse, who also went on to earn a master's. Currently, Moore and Clarke are working together to secure funding to restart dual-degree opportunities while expanding the summer research experience.

In a similar vein as the Fort Valley State program, Associate Dean Christopher Bell and lecturer Mary Poteet are working to recruit Austin Community College (ACC) students as transfer students to the Jackson School through shared student outings. The goal is to have ACC students transfer after two years and come into the school with a student network already established. In 2019, Bell led a student outing to the Jackson School's White Family Student Learning Center, where students found and identified fossils across the 266-acre property. One former ACC geoscience student has successfully transferred to the Jackson School due to the partnership. However, external funding is required to establish the effort as a permanent program.

Poteet and Bell are applying for grants to fund it. Once a student is enrolled in the Jackson School, funds from a number of endowments help make education more affordable. (See sidebar on page 49 for more information.)

Internal Support

In July 2020, Kristen Tucek, the Jackson School's associate director for alumni and corporate relations, hosted a virtual meeting with a handful of alumni who were interested in learning more about diversity and inclusion at the Jackson School.

An exchange between Shin and fellow alumnus Ted Cross provided a poignant example of how a person's race may affect how that person is treated in subtle, yet meaningful ways.

Cross, who is white, recalled professors and later managers telling him that he reminded them of younger versions of themselves. Shin never heard those words, despite having many of the same professors, being in the same classes and graduating with a Bachelor of Science the same year that Cross did. It's difficult to pin down whether race was the reason. But, combined with years of other experiences in which Shin was treated differently—both inside and outside of the Jackson School—it raises the question. Starting this summer on social media, numerous Black scientists used the hashtag #BlackinSTEM to

ONRAMPS: JACKSON SCHOOL FOSSIL HUNTING; CHRISTOPHER BELL.

PHOTO: STANLEY STACKHOUSE.

OPPOSITE PAGE, TOP: HIGH SCHOOL SCIENCE TEACHERS DURING A UT ONRAMPS TRAINING SESSION AT THE JACKSON SCHOOL IN 2019. **OPPOSITE PAGE, BOTTOM:** GEOSCIENCE STUDENTS FROM THE JACKSON SCHOOL AND AUSTIN COMMUNITY COLLEGE ON A JOINT FOSSIL HUNTING TRIP AT THE WHITE FAMILY OUTDOOR LEARNING CENTER IN 2018.

ABOVE: STANLEY STACKHOUSE PARTICIPATING IN A GEOSCIENCES OUTREACH EVENT SPONSORED BY SHELL. STACKHOUSE EARNED A BACHELOR'S AND MASTER'S DEGREE FROM THE JACKSON SCHOOL AND NOW WORKS IN THE ENERGY INDUSTRY.

share their own experiences of being treated differently, and the toll it can take on feeling welcome in a scientific community in which they are a minority.

Two groups at the Jackson School are working to combat that outsider experience by creating a more inclusive community within the school. One group, **GEN (Geoscience Empowerment Network)**, is doing that by helping members build a broader understanding of diversity and inclusion issues in geosciences, and advocating for ways to bring more diverse geoscientists to the Jackson School. The other group, GeoLatinas, is creating a space for Latinas and others to build community, network and support with one another.

Professor Ginny Catania founded GEN in 2018 with an initial focus on professional development and community building for women and racial minorities across all groups in the Jackson School. Since this summer, GEN has received a jolt of new energy, with members discussing ways to promote inclusivity across the school. Plans include a peer mentorship program for graduate students, diversity and inclusion workshops, a reading and discussion group about diversity in STEM, targeted policy changes, and advocating for more diverse speakers at the Jackson School's DeFord lecture series.

Whereas GEN is a Jackson School-specific group, GeoLatinas is a global organization with chapters in eight countries. In spring 2020, Gomez and fellow doctoral student Estefania Salgado Jauregui founded a chapter at the Jackson School.

They had one in-person meeting before COVID-19 turned all organizing virtual. Nevertheless, Gomez and Salgado Jauregui have big plans for recruitment and community building for the fall—from outings to Latin American museums, talks from Latina leaders in geosciences, and organizing holiday activities.

The organization centers on Latina students, but everyone is welcome to join. Gomez said her goal is to build connections within GeoLatinas but also create a larger network among other Jackson School groups—including GEN, the Graduate School Executive Committee and Geosciences Leadership Organization for Women.

"This is how we're going to grow and contribute to the mission of the Jackson School," said Gomez. "The No. 1 thing is having diversity as a central aspect of the overall academic realm and as a long-term thing.

The Path Forward

Taken in total, the programs and efforts being made at the Jackson School do show a clear commitment to diversity, said Mora, who pointed to herself as a living example.

"The Jackson School selected a dean who had spent the previous 12 years outside of academia (at Los Alamos National Laboratory) and who is a Latina," said Mora, whose career also included 18 years as a professor at the University of Tennessee, Knoxville. "That's not the way most places would have gone about it."

Turning that commitment into better results is going to take improvement across the board and stepped up coordination and communication.

FIELD TRIP: GEOFORCE. GOMEZ: KIARA GOMEZ.

Many of the Jackson School's programs are grassroots efforts and have sprung up separately from one another, creating a situation in which it is difficult for those not directly involved with diversity programs to know what's going on.

Along with refining current programs, the Jackson School is figuring out clear ways that the alumni can plug in and assist with the effort.

As the incoming president of the Jackson School's Friends and Alumni Network, Stackhouse said that one of his key priorities is advancing geosciences outreach, especially in the Houston area. Shin is doing related work as a member of the Geological Society of America's diversity committee, advocating for scholarships that bring geosciences students from underrepresented groups to the society's annual meeting.

They both said that they think one of the biggest ways the school could help increase underrepresented students is by hiring faculty members from these same groups.

"It's hard to tell people that you're diverse, and you're bringing diverse students in, and the student starts looking and says, 'There's nobody like me that teaches there,'" Stackhouse said.

Given the breadth and depth of the problem, Mora said, the energy and interest of alumni is essential. She summed it up when talking with a group of concerned alumni.

"Please don't just tell us what to do. Find something that you can do, and help us do that," she said. "We are glad you're listening, and yes, it's painful. But join us, and help us, and take measurable steps toward progress."

OPPOSITE PAGE, TOP: 2019 EDGE PARTICIPANTS VISITING THE BUREAU OF ECONOMIC GEOLOGY'S CORE RESEARCH FACILITY.
OPPOSITE PAGE, BOTTOM: DOCTORAL CANDIDATE KIARA GOMEZ WITH ROCK CORES IN NORWAY. GOMEZ IS A LONGTIME MEMBER OF THE JACKSON SCHOOL'S DIVERSITY AND INCLUSION COMMITTEE AND THE COFOUNDER OF THE SCHOOL'S GEOLATINAS CHAPTER.

ABOVE: GEOFORCE STUDENTS AUDREY URAIH (LEFT) AND JAMES SUN MEASURE THE STRIKE AND DIP OF AN OUTCROP AT PEDERNALES FALLS STATE PARK IN 2012.

PHOTO: OFFICE OF BROADER IMPACTS OF GEOSCIENCE RESEARCH.

PAYING FOR SCHOOL

Being able to afford an education is an obstacle for many students. Once a student has finished an undergraduate degree and been admitted as a graduate student at the Jackson School of Geosciences, the obstacle is largely overcome. The school provides full funding packages for the vast majority of its graduate students. The exceptions are students with outside funding sources—such as grants or company funds—and students enrolled in the multidisciplinary Energy and Earth Resources program. Funding includes full tuition, health insurance and a stipend for living expenses.

The situation is trickier for undergraduates. When students apply, they are automatically considered for scholarships that they may qualify for based on a number of factors. In all cases, the scholarship amounts vary each year depending on the funds available in endowment accounts.

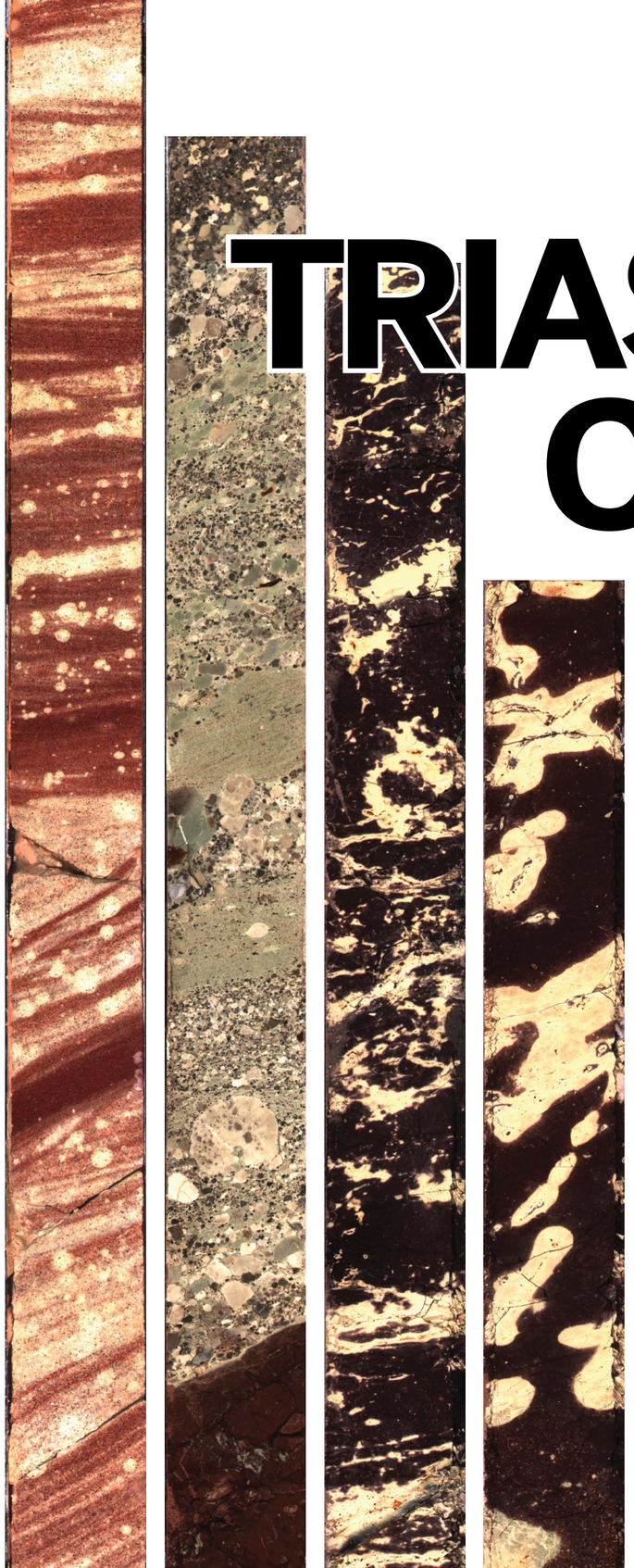
The Jackson School has 97 student endowments that help students pay for education. About 14% of these endowments are working to increase student diversity by providing funds specifically to students who are first-generation college students or GeoFORCE alumni. (Due to legal reasons, donor designations cannot take race or ethnicity into account.)

The vast majority of endowed funds provide funding for students across the school: All Jackson School students with at least a 3.5 GPA receive a scholarship starting after their first semester, and those with financial need receive an additional scholarship.

The school's student endowments also fund recruitment scholarships. For the past three years, two prospective undergraduates have been offered a $10,000 recruitment scholarship. For these scholarships, diversity is taken into account.

However, the endowments are not sufficient to guarantee these top students a similar level of funding for the rest of their undergraduate studies. In some cases, this situation has led to recruited students leaving the school due to financial hardship, said Bell, who added that his top fundraising priority is creating an endowment specifically for extending the recruitment scholarships to a full four years.

Even as the Jackson School continues raising funds to support students, The University of Texas at Austin's new Texas Advance Commitment policy is helping make a college education possible for people who would not otherwise be able to afford it. The policy, which went into effect this fall, covers tuition for undergraduate students from Texas families making less than $65,000 a year and provides support for students from Texas families making less than $125,000 a year.



TRIASSIC CORE

A QUARTER-MILE ROCK CORE IS SHEDDING LIGHT AND RAISING QUESTIONS ON THE TURBULENT EVENTS THAT SET THE STAGE FOR THE RISE OF THE DINOSAURS

BY ANTON CAPUTO & MONICA KORTSHA

PHOTO: A SELECTION OF TRIASSIC CORE SECTIONS FROM PETRIFIED FOREST NATIONAL PARK. THE ENTIRE CORE IS NEARLY A QUARTER-MILE LONG AND OFFERS A CONTINUOUS RECORD FOR ALMOST THE ENTIRE TRIASSIC PERIOD. CREDIT: CORNELIA RASMUSSEN.

LAKE: NASA. CORE: RANDY IRMIS/NATURAL HISTORY MUSEUM OF UTAH. RASMUSSEN: RANDY IRMIS/NATURAL HISTORY MUSEUM OF UTAH.

The Triassic remains one of the most consequential and mysterious geological periods in Earth's history.

It is a time of evolutionary change, bookended by two mass extinctions and the diversification of early dinosaurs into the wealth of forms that would rule the planet during the Jurassic.

It is also a time of environmental transformation, especially during the Late Triassic, which saw the breakup of the supercontinent Pangaea, pulses of volcanic activity, and at least three asteroid impacts—the largest being the Manicouagan impact in what is present-day Quebec.

On the regional scale, in what is now Arizona's Petrified Forest National Park, the fossil record shows a "biotic turnover"—a shakeup in the local ecosystem that caused some species to go extinct and others to appear—happening in the middle of the Late Triassic. The timing has prompted debate about whether this turnover could be connected to broader environmental changes.

LEFT: LAKE MANICOUAGAN AS SEEN FROM SPACE. THE LAKE FILLS A CRATER LEFT BY A METEORITE IMPACT 215.5 MILLION YEARS AGO IN WHAT IS NOW QUEBEC, CANADA.
MIDDLE: A SHOT OF THE TRIASSIC CORE. THE CORE IS HELPING RESEARCHERS CREATE A GEOCHRONOLOGICAL RECORD THAT MAY HELP SCIENTISTS LINK ECOLOGICAL CHANGES RECORDED IN THE FOSSIL RECORD TO ENVIRONMENTAL EVENTS
RIGHT: RESEARCH ASSOCIATE CORNELIA RASMUSSEN PREPARES TO SPLIT A CORE SAMPLE.

Different hypotheses have surfaced. Some think the Manicouagan impact event may have caused a sudden shift in the animal and plant community, while others point to regional tectonic events such as the rise of the Cordilleran Arc or global paleogeographic changes induced by the breakup of Pangea.

But a major barrier to evaluating these hypotheses has been the lack of a continuous geochronological timeline that can be used to improve estimates of the ages of animal and plant fossils found in the park and the timing and tempo of environmental change. Cornelia Rasmussen, a research associate at the University of Texas Institute for Geophysics (UTIG), is part of an ambitious project to fill in the gaps in the geological timeline and solve the mystery.

"If you do not understand the timing of different events, you are not able to correlate them with one another," Rasmussen said. "Without understanding the timeline, you continue to arm wave, which can be fun, coming up with various hypotheses, but you never get around to really test them."

She has been working on the puzzle since 2013, when, as a doctoral candidate at the University of Utah, she became a science party member of the Colorado Plateau Coring Project's expedition to take a nearly quarter-mile-long core from Petrified Forest National Park. The core offers a continuous, unbroken stretch of Earth's history for almost the entirety of the Triassic—including the tumultuous Late Triassic. It also preserves a geologic section called the Chinle Formation, which is known for its rich array of fossils preserved in outcrops in the national park.

"The core lets us wind the clock back to when the Petrified Forest National Park was a tropical hothouse populated by crocodile-like reptiles and turkey-size early dinosaurs," Rasmussen said. "We can now begin to interpret changes in the fossil record, such as whether changes at the time were caused by an asteroid impact or slow geographic changes of the supercontinent drifting apart."

Divergent Timelines

Rasmussen is especially intrigued by the impact hypothesis. Asteroids have struck the planet many times throughout its history, but scientists have few models of their broader ecological and environmental significance. Rasmussen was part of the science team that analyzed cores taken from the crater of the Chicxulub impact, which wiped out the dinosaurs 66 million years ago. (UTIG Research Professor Sean Gulick co-led the mission to recover the core from the buried crater in the Gulf of Mexico in 2016.)

But Chicxulub isn't representative of most impacts. The mass extinction that followed had much to do with where the asteroid landed—a continental shelf made up of sulfur-rich carbonate rocks that wreaked more havoc on the global climate than the impact itself. By placing the Manicouagan event, which occurred 215.5 million years ago, on a geologic timeline with other

TOP: RASMUSSEN AND DOMINIQUE GIESLER OF THE UNIVERSITY OF ARIZONA SAMPLING DIFFERENT PARTS OF THE CORE FOR GEOCHRONOLOGIC DATING AND STABLE ISOTOPE ANALYSIS.
BOTTOM: KRISTINA BRADY OF THE NATIONAL LACUSTRINE CORE FACILITY PREPARING A CORE FOR TRANSPORT AT THE DRILL SITE AT PETRIFIED FOREST NATIONAL PARK IN 2013.

events, Rasmussen said that scientists might be able to learn whether impacts with less spectacular landing sites can still have significant effects.

"We have so many impact sites that are nothing like Chicxulub," she said. "That's why I found this question initially very intriguing to say, 'OK, we have a big crater but what did this crater actually do to the terrestrial environment?'"

However, placing the impact and the turnover on the timeline recorded in the core's rocks turned out to be not so straightforward.

A study led by Rasmussen and published in the *Geological Society of America Bulletin* in July 2020 found that the geochronologic age models for the core differ depending on the interpretation of the data analyzed in the study.

The researchers used two methods to determine ages of different core sections. The first method involved extracting tiny crystals of the mineral zircon from the core. Zircons are spewed into the sky during volcanic eruptions and, when combined with uranium-lead (U-Pb) dating, act as a time stamp for the sediments. The second method relied on magnetostratigraphy, a technique that creates a timeline based on signatures of ancient magnetism preserved in the rocks.

The team used the two data sets to create two model timelines that tracked ages and sedimentation rates over time. They both used zircon U-Pb ages and magnetostratigraphy, but one gave preference to the zircon U-Pb data and the other to the magnetostratigraphy.

Although the two models agreed in the upper half of the core, they differ in the lower half—the section that contains both the Manicouagan impact event and the biotic turnover.

The model that gave preference to the zircon U-Pb ages found that the section covering the time of the impact and the biotic turnover suffered from very low sediment accumulation, with only 4.5 meters per million years deposited. This could mean that what looks like a biotic turnover at Petrified Forest National Park could just be the result of a sediment hiatus that resulted in fewer fossils being preserved. If this is the case, it suggests that changes in flora and fauna occurred rather gradually and were not abruptly driven by the asteroid impact.

In contrast, the model that gave preference to the magnetostratigraphy found that the section was deposited much more rapidly, with an average of 34 meters of sediment per million years. In this case, the model allows for a correlation of the asteroid impact event and the biotic turnover.

Coming up with two potential answers is not ideal, but Adam Marsh, the lead paleontologist at Petrified Forest National Park, said that having two plausible hypotheses represents a great leap forward in filling in the timeline that will eventually provide a single robust answer.

"When you read [the study], first you say, 'Well that's a problem,' but it's not," he said. "It's going to help guide, not only future clarifying studies for this project, but also how we sample in the next core."

PHOTOS: RANDY IRMIS/NATURAL HISTORY MUSEUM OF UTAH.

PROJECT SITE: RANDY IRMIS/NATURAL HISTORY MUSEUM OF UTAH. SKULL: NATIONAL PARK SERVICE.

TOP: THE COLORADO PLATEAU CORING PROJECT SITE AT PETRIFIED FOREST NATIONAL PARK, NEAR THE FAMOUS DEVIL'S PLAYGROUND SECTION OF THE PARK.
BOTTOM: THE SKULL OF A PHYTOSAUR, AN EXTINCT REPTILE THAT LIVED DURING THE LATE TRIASSIC IN WHAT IS NOW PETRIFIED FOREST NATIONAL PARK. THE FOSSIL RECORD SUGGESTS THAT THEY WERE AMONG THE SPECIES THAT UNDERWENT A BIOTIC TURNOVER DURING THE LATE TRIASSIC.

Marsh was not part of the 2013 coring expedition, but he has been aware of the study since its early stages and will be part of a second coring project if and when it is funded. He is interested in the work because the park contains a rich collection of fossils from the late Triassic, but until now there was little information on the timeline because most of what scientists knew came from studying outcrops of exposed rock pushed to the surface by tectonic movements. This makes it difficult to address fundamental questions, Marsh said.

"Because we have so many fossil localities throughout the entire section, we can look at things like macroevolution and changing evolution through time, but we can't do that if we can't talk about time," he said.

Marsh also provides another link between the Colorado Plateau Coring Project and the Jackson School of Geosciences. He earned a Ph.D. from the school in 2017, his master's in 2013, and he holds an appointment as a research associate at the Jackson School Museum of Earth History.

Next Steps

With the two models in hand and plenty of questions still unanswered, Rasmussen and her colleagues are continuing the work. Rasmussen has been awarded a seed grant from The University of Texas at Austin Center for Planetary Systems Habitability (CPSH) for fieldwork on outcrops in Arizona. She is also awaiting the results of age testing on a thick red silcrete layer in the lower Jim Camp Wash beds of the Sonsela Member that is used as a marker for the biotic turnover in outcrops in the park.

Since the core lacks such a distinct marker of the biotic turnover, getting a precise age from the silcrete layer from outcrops could tip the scale toward one model or another.

"It's just so fundamental, nailing down the age of this marker bed," Rasmussen said.

The research is uncovering a detailed look at our planet's past and the potential role played by impacts—or not—in affecting ecology and evolution. Gulick, who is the co-director of the CPSH, said that this topic is important to the center because impacts shape environments on other planets.

"Impacts are the dominant geologic process on most planetary bodies, and their effects on local and global environments are of intense interest," Gulick said. "In particular, it's critical to understand potential deleterious effects such as changing climate and positive effects such as creating astrobiological habitat."

The team of the Colorado Plateau Coring Project has submitted a proposal for the second phase of drilling. Partners on this project include researchers from Columbia University; Rutgers University; University of California, Berkeley; University of Arkansas; and the University of Utah.

This phase would pull cores that go across the end Triassic extinction into the Jurassic and will collaborate with the Early Jurassic Earth System and Timescale program in the United Kingdom that is drilling into end Triassic and early Jurassic marine records.

"Something we are missing is the correlation of the terrestrial with the marine environment and how they were affected by the same environmental changes," Rasmussen said. "This is one of the questions that are currently being worked on and hopefully being funded in the future."

FACE MASKS, ZOOM AND GEOSCIENCES

HOW THE JACKSON SCHOOL IS HANDLING CORONAVIRUS

BY ANTON CAPUTO & MONICA KORTSHA

On Aug. 26, 2020, the first day of the fall semester, it was empty and quiet on The University of Texas at Austin campus. That's because for most students and faculty members, going to class meant logging on to their computers from home.

By this point, they had plenty of practice. The onset of the coronavirus pandemic shut down campus in March and transitioned all classes online. And although the university went into the summer with high hopes for a return to in-person learning, by the start of the fall semester only about 5% of classes were happening face to face, or more accurately, face mask to face mask. About 76% of classes remained online, and 19% were hybrids that combined online learning with in-person components.

Keeping the UT community safe during the pandemic has touched every aspect of university life. Mainly, it has meant finding ways to do things apart that were once done together. Just 16 days into the semester, UT accounts racked up a total 1,219,621 hours on the remote conferencing platform Zoom, which is being used for everything from meeting with colleagues to lectures.

At the Jackson School of Geosciences, it has meant transitioning to whole new ways of teaching geosciences classes, conducting research and building community.

PHOTO: ASSOCIATE PROFESSOR ELIZABETH CATLOS TEACHES EARTH MATERIALS, ONE OF THE FEW IN-PERSON CLASSES THIS FALL. ZIP-TIED SEATS HELP MAINTAIN SOCIAL DISTANCE. CREDIT: JACKSON SCHOOL.

Note: The UT and Jackson School coronavirus response is a constantly evolving situation. Some parts of this article might be out of date by the time of publication. For the latest news on the UT coronavirus response, visit: ***coronavirus.utexas.edu***.

The Beginning

The transition officially started March 17, 2020, when then-UT President Gregory L. Fenves announced that all classes would be moving online for the remainder of the spring semester.

Faculty members, researchers and staff members throughout the university faced a monumental task. They had just two weeks to transition classes to a virtual setting, communicate the new reality to students, and prepare for a whole new way of teaching and operating the university. That's not to mention setting up funds for students with emergency needs such as providing a computer and access to the internet, along with more pressing issues such as assistance with food, rent and medical bills.

All in all, the UT-wide efforts involved moving more than 49,000 students online in more than 9,000 classes. For then-undergraduate student Rachel Breuning, who graduated from the Jackson School later in the spring, it meant rushing back to Austin with her parents to grab her belongings from the residence hall and heading back to Houston, where she finished the remainder of the semester from her childhood bedroom.

"It's happening to everyone, so I don't feel like I have a right to feel that bad about it," Breuning said. "I feel we all are just kind of doing the best we can with what we have."

During these tumultuous early days, UT and the Jackson School stressed compassion in education, making accommodations wherever possible.

"The greatest challenge has been to always remember to be aware of the very different circumstances that our students may find themselves in, with respect to having the electronic resources, the bandwidth, the time and space, and support at home to do their schoolwork," said Jackson School Dean Claudia Mora. "For some, this change placed them in environments where meeting their educational goals can be very, very difficult. Faculty and staff have faced their own challenges, as many are also sharing their workspace with children home from day care or school, and spouses who are also trying to work from home. We have had to all develop greater sensitivity to each other and greater flexibility in our expectations."

Gearing Up

All schools and colleges faced their own obstacles. But for the Jackson School, with its focus on hands-on experiential learning, the difficulties were significant. Taking students to the field was out, as was working in the lab and the tactile experience of handling specimens.

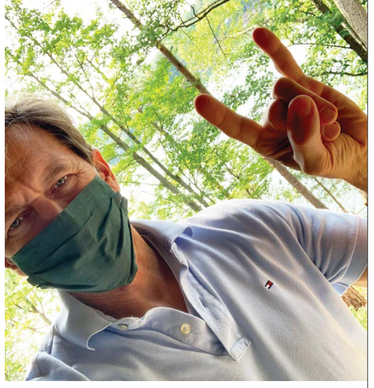
The job of spearheading the Jackson School's sprint to online classes fell to a volunteer ad hoc committee led by professor and incoming chair of the Department of Geological Sciences Daniel Stockli, writer-in-residence Adam Papendieck, and IT staff members Adrian Huh and Tyler Lehman. The committee has remained an invaluable resource into the fall semester, said Associate Professor Elizabeth Catlos, with the team providing advice on a variety of online learning needs ranging from microphones to managing meeting security.

"That group provided a great service to make the transition to online teaching less of a challenge," Catlos said.

Papendieck had significant experience with online learning in a previous position at Tulane University, where he developed systems and programs to support international health sciences education, particularly in eastern Africa. He also had the experience of helping Tulane reopen after Hurricane Katrina ravaged New Orleans in 2005.

There are some benefits to the frenzied energy of an emergency, he pointed out: No one balked at embracing the new environment. Everyone recognized the need and committed to do their best to adjust.

More importantly than just mastering the technical challenges, however, were the sessions on how best to create an interactive and effective online learning environment, how to take advantage of online resources and how to handle online assessment and testing.



SELFIES: SCOTT TINKER, CLAUDIA MORA, DEMIAN SAFFER. STUDENT: JACKSON SCHOOL.

Most instructors had little or no experience with online teaching, meaning they were entering a whole new world of education and instruction, Stockli said.

"We urged instructors to maintain a rhythm, including maintaining class times and office hours," Stockli said. "We advised instructors of small classes to continue live lectures via Zoom and make the recording available via internally accessible cloud archives in Canvas. In contrast, large classes were advised to either go live or with prerecorded 15-minute segments interspersed with live discussions."

During this transition to a new learning model, graduate teaching assistants were among those who were leaned on the hardest, Stockli said. Typically, teaching assistants learn to teach by watching their mentors. But in this situation, there was no playbook or example, and they often were the ones with the important job of leading students in labs and other small group settings.

"They were transformed into instructional designers overnight in a way that they hadn't before," Stockli said. "And we really stressed with TA's that they are absolutely essential in community building. We emphasized that they cannot just be instructors but have to be the connection to the students."

This reality hit home with Alexandra Lachner and Jaime Hirtz, who were teaching assistants in the spring field methods course.

They quickly found themselves helping students navigate virtual field outings largely on the fly and spending additional time offering support and guidance to students. They extended office hours and met students one-on-one for virtual meetings. Although they both embraced the expanded role to help students succeed during this difficult time, they said that the more frequent and instantaneous access could be tiring, particularly as they pursue their own graduate work and deal with their personal situations.

"It's been more difficult in that respect," Lachner said. "We are in a situation that's kind of nonstandard, so you kind of have to roll with it."

OPPOSITE PAGE, TOP 3: JACKSON SCHOOL LEADERS SHARED "MASK SELFIES" FOR UT'S "PROTECT TEXAS TOGETHER" CAMPAIGN. FROM TOP TO BOTTOM: SCOTT TINKER, DEMIAN SAFFER, CLAUDIA MORA.
OPPOSITE PAGE, BOTTOM: GEOSCIENCES STUDENT APRIL DELEON ATTENDING AN EARTH MATERIALS CLASS.

BELOW: 383 ROCK KITS AWAITING PICKUP BY STUDENTS. THESE PERSONALIZED KITS ENSURED THAT STUDENTS COULD STILL WORK WITH REAL SAMPLES WHILE LEARNING REMOTELY IN THE FALL.

PHOTO: CHRIS STELLA.

The Remote Classroom

The move to online classes was more seamless for some than others.

Jud Partin, a research associate with the University of Texas Institute for Geophysics (UTIG) who teaches an advanced statistics class for graduate students, had already introduced Zoom meetings in 2019 as a way of bringing together students based at different UT campuses.

However, there are still reminders that these are far from normal times.

Partin's class now includes occasional interruptions from his 4-year-old.

"Fortunately, everyone's quite forgiving these days," Partin said.

Other classes presented more difficulties. In field methods, the class went from traversing outcrops themselves to controlling an avatar in a virtual field experience that resembled a computer video game. In the virtual field, students still had to make maps and generate a geologic history. But collecting the data from outcrop entries in a digital field notebook just wasn't the same, said Barbara Sulbaran, an undergraduate who took the course during the spring.

"I can't physically look at the rock. All of what you're supposed to do is already done," she said. "I love my field notebook, and I haven't had to look at it [since quarantine]."

And in large lecture classes, connecting with students through a screen proved to be a challenge.

Assistant Professor Daniela Rempe and Professor Richard Ketcham were co-teaching Introduction to Geology when the course first shifted to online learning during the spring. About 115 students should attend each lecture, but online only about 40 to 50 showed up——a number that Rempe said she was fairly happy with given the situation.

The course was conducted over Zoom and blended prerecorded lessons with real-time discussions and interactive exercises. And while Rempe found that students were quick to use the chat function to ask questions during class——a nice change from the large lecture halls where it was rare for students to raise their hands and pose questions——hardly anyone would turn on their

cameras or microphones. Rempe was left addressing a screen of dozens of blacked-out little boxes.

"Maybe they are on their phone or maybe they don't want us to see where they live," Rempe said. "It's hard to say why they do that, but that part has been very frustrating."

With guidance from UT leadership, the Jackson School spent the summer developing two plans for teaching during the fall semester. The first plan prioritized face-to-face learning. The second plan was a hybrid model in which online classes were prioritized while still allowing for classes that blended online and in-person learning, as well as a small number of only in-person classes.

In early June, when the coronavirus infection rate had plateaued in Austin, there were high hopes that the fall semester would mean in-person learning for most everyone, said Charles Kerans, the chair of the Department of Geological Sciences. However, a spike in COVID-19 cases in early July finalized the decision to prioritize online learning.

This fall, about 56% of Jackson School classes—30 out of 53—are being taught exclusively online. Almost all the rest are available as two options: online or hybrid courses that blend in-person and online learning.

Introduction to Geology—the same class that Rempe and Ketcham taught entirely online during the spring—is now a hybrid course and taught by Associate Professor Tim Shanahan. Usually, the course would be capped at about 250 students, the maximum capacity of the Jackson School's largest lecture hall, the Boyd Auditorium. But online learning has allowed the course to take on more than double that amount. The 550 total students currently enrolled across the two class sections is a record breaker.

"It's nice to see there's so much interest in geology, and the feedback I'm getting from students is that they're really excited about it," Shanahan said. "But teaching on Zoom, when you look down and see that you're at like 275 people is a little bit crazy."

Shanahan said that students are still hesitant to turn on their cameras and microphones. He faces the same screen of black boxes as Rempe. But he is working to promote engagement in other ways. He changes the Zoom background to match the lecture material. (For introductions on the first day of class, Shanahan, a paleoclimatologist, opted for a photo of him and graduate students taking a sediment core from a lake.) He also streams music from the class Spotify playlist, which was started by Rempe, as students log in for lectures. Sometimes he plays student requests. But he can't resist matching the song to the lecture when the opportunity arises. A lecture on continental drift started with Sia's "Unstoppable."

Shanahan has also made a point to check in with the freshmen in the class at the start of the semester, organizing smaller Zoom sessions of about 20 people to answer questions and provide guidance. He is hosting similar sessions with international students, who face their own unique challenges, such as making sure they can take an exam at a decent hour in their time zone.

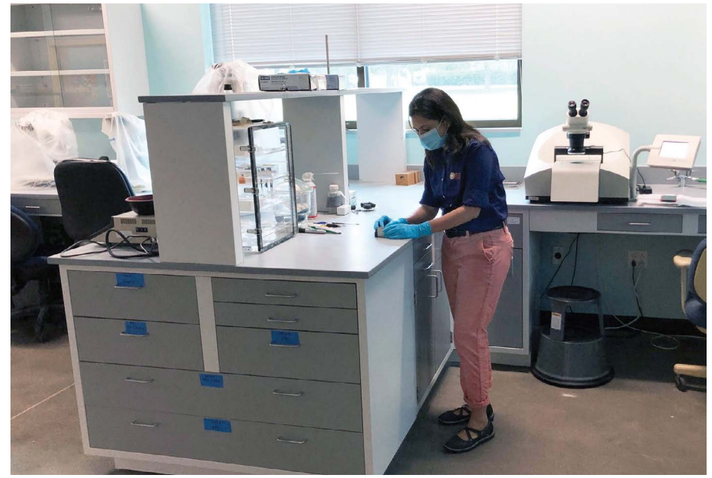
PHOTO: JACKSON SCHOOL.

Hands-On Learning Near and Far

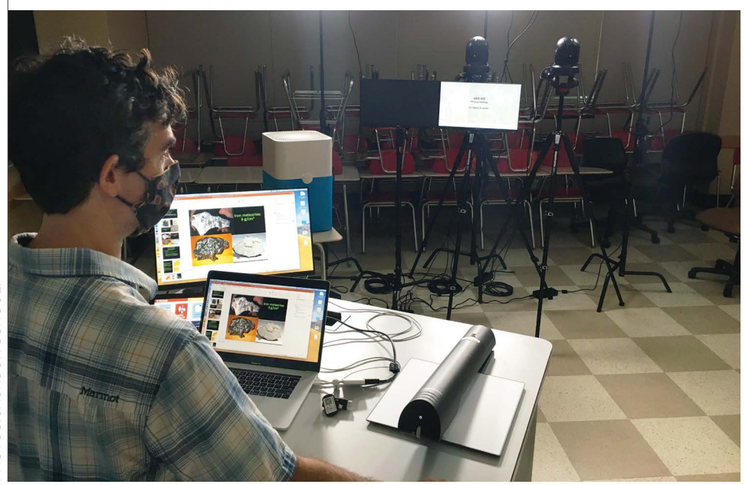
During the spring, the quick shift to online learning meant that students enrolled in Introduction to Geology did not have access to rock and mineral specimens that they would usually examine in the course's lab sections. They made do by studying structure and faulting with paper models. This fall, making sure that remote and socially distanced learning still included real rocks was a top priority. The Department of Geological Sciences ordered a total of 632 custom rock kits—each containing 30 specimens—for every student enrolled in Introduction to Geology and Physical Geology. Students taking the course entirely online had their kits mailed to them, with some kits going as far as Saudi Arabia. To offset the $60 cost of the kits, Shanahan wrote the lab manual for the courses and provided it to the students for free.

Earth Materials is one of the few classes with an in-person option available for both lecture and lab, along with online and hybrid options. For some classes, students bring rocks and minerals from the lab to lecture in plastic containers. The course instructor, Associate Professor Elizabeth Catlos, also has larger samples—which she disinfects with a generous spray of Lysol before class—arranged on a table at the front of the classroom.

"If this course was offered only 100% online, I think the students would have a huge disadvantage," Catlos said. "They are taking a field class after this, so how do you do a field class without working with hand specimens first?"



The in-person class meets in the usual lecture space of the Boyd Auditorium, but with a number of safety precautions in place. Most of the seats are zip-tied closed, leaving only socially distanced spaces available. Arrows on the floor mark walkway directions. Two poster displays at the front and the back of the room serve as cleaning supply caddies. And everyone wears a face mask, with Catlos opting for a clear plastic one when she is lecturing so students can lip-read and see her facial expressions.



PHOTOS: JACKSON SCHOOL.

For the course's in-person lab, maintaining social distancing has required students in the same lab section to be split up across two classrooms at opposite ends of a hallway. At first, this presented a problem because a sole teaching assistant teaches the lab. But installing a digital doorbell between the classrooms has proved to be a quick fix, Catlos said. Students simply ring if they need to call the TA for questions or need help.

The doorbell is a creative solution to a less than ideal situation. The ultimate goal is to have classes where everyone can be together again someday. However, some of the technological workarounds have, in some cases, proved to be advantageous over in-person learning. Like Rempe, Shanahan has noticed an uptick in student questions using chat. And Associate Professor Daniel Breecker, who livestreams his Physical Geology class from a classroom turned recording studio,

OPPOSITE PAGE: DEPARTMENT CHAIR CHARLES KERANS (IN WHITE HAT) OPTED FOR AN OUTDOOR CLASSROOM FOR HIS CLASS ON CARBONATE AND EVAPORITE DEPOSITIONAL SYSTEMS.

ABOVE: RESEARCH SCIENTIST AND LAB MANAGER PRIYANKA PERIWAL AT WORK IN THE SCANNING ELECTRON MICROSCOPE LAB AT THE BUREAU OF ECONOMIC GEOLOGY.
BELOW: ASSOCIATE PROFESSOR DANIEL BREECKER UNDER STUDIO LIGHTS WHILE LIVE STREAMING A LECTURE.

said that he is planning on bringing the digital polling he has integrated into his remote lectures back into the classroom with him, whenever that may be.

"In person, you ask a question but only one person will answer. So this actually is an improvement," he said. "This is an opportunity to try out some stuff and see what I like and figure out how to incorporate it into the class when all this is over."

Return to Research

When UT shifted to online learning in March, laboratory and fieldwork were put on pause. Some projects were able to adjust to remote work. Assistant Professor Tim Goudge is still studying Martian geology using remote sensing data from satellites. And during the spring, doctoral student Omar Alamoudi made good progress on building a machine for rock physics experiments in his home office.

But for many Jackson School scientists, getting back to research meant getting back to the lab. At the Department of Geological Sciences, Associate Dean for Research David Mohrig led the charge to do so safely. The school quickly put in place a rotating schedule for researchers to keep lab density low, and a check-in system to keep track of people in case of the need for contact tracing. (So far, there have been no cases of coronavirus spread tracked back to laboratory work). Within two weeks of the university's closing, 20 researchers were able to return to the lab. By August, that number was 360, about 80% of the school's research staff.

For the fall semester, research and classes are being kept completely separate, Mohrig said, a setup that can potentially keep research going even if all classes shift to remote learning again.

"If the classrooms have to close again, the research can continue," Mohrig said. "We don't have to rebuild that enterprise."

The Jackson School's two research units, the Bureau of Economic Geology and UTIG, are abiding by similar research protocols as the department. Most of the bureau's 15 labs are up and running, along with its core research center, which has set up socially distanced core-viewing areas. At the institute, most research is able to continue remotely. However, the field missions and scientific cruises on which much of the raw data is collected have been put on hold.

Local fieldwork has resumed on a case-by-case basis. Bureau researchers are maintaining TexNet seismometers across the state. In late July, graduate student Chris Linick travelled to the McDonald Observatory in West Texas to repair a gravimeter (See page 75). And although two of the Jackson School's field camps were canceled during the summer, the school's capstone field geology course, GEO 660, continued — but in a scaled-down, socially distanced form. (See page 68).

Kerans is continuing to bring Jackson School students into the field this fall as part of his course on carbonate and evaporite depositional systems. He opted for a field setting for the course's labs, which is better suited than the classroom for social distancing — and for fresh air, he notes.

Although field research overall has been scaled back, when it comes to sharing research results, going remote has been a boon for lectures and seminars.

Catlos said that the Jackson School's DeFord Lecture Series has undergone a revival of sorts now that they're streamed over Zoom and open to the public. Attendance at recent talks has been about 200 people, with scientists from across the world tuning in.

Zoom seminars at the bureau and UTIG have also seen a bump in attendance. And according to the latest cohort of doctoral students, presenting their dissertations over Zoom enabled more people to attend — from friends and family, to research collaborators, advisers and even potential postdoctoral research collaborators.

"It was really nice to be able to invite people that I would like to work with," said Chelsea Mackaman-Lofland, who earned a doctorate in April.

Looking Ahead

Thomas Quintero finished his final semester at the Jackson School in the spring.

Like many students, he was able to go home to his family to finish the semester. Between his senior thesis, finishing classes and helping his older brother renovate a home he just bought, it was a busy end to the semester. In all honesty, he said, he was ready for school to just be over so he could focus on the next phase of life.

Nevertheless, he was glad he could close out his college career with a graduation ceremony. He wasn't able to walk across a stage. But he was able to gather with close family to watch the Jackson School's virtual commencement ceremony. Quintero said that they paused the video to take pictures in front of the slide that listed his name alongside Bachelor of Science in Geological Sciences.

"I'm thankful there was something," said Quintero, who is now putting his geology degree to use as an intern at an organization that is using geospatial analyses to determine where water capture systems should be built in Detroit, Michigan, neighborhoods so residents' drainage fees can be reduced. He plans to attend graduate school later on.

Remote and socially distanced learning has changed everything this year — from introductory geology classes to graduation. Although it's hard to say how long it will remain the norm, the Jackson School community is working to constantly adapt, improve and remain resilient to a whole new way of being geoscientists.

Walter Geology Library 2019–20 Annual Report

As I write my 35th and final Walter Library Report in the middle of the pandemic lockdown, I want to start by reflecting on what an honor and a pleasure it has been to work over the decades with the students and researchers of the Jackson School. Much has changed since 1985, and even now, much remains the same, but the pursuit of excellence in earth sciences research and teaching at the Jackson School remains a constant. Thank you for allowing me to participate.

Last year, in planning for my retirement, I developed a multipage punch list of projects large and small to be completed or organized for my successor. With funding finally in hand, renovations to the west end of the library to move and enhance the Jackson School gem and mineral display were due to commence. A new excellence fund would give future librarians greater flexibility to take on special projects, travel and do research, acquire special collections, or take advantage of other opportunities. A review of the entire collection was well under way, selecting about 30% of the low demand print collection for relocation to the newest storage facility, with the intention of reducing risk in water damage prone areas, and creating more space for new materials and for users. Negotiations were underway with several Latin American and Middle Eastern vendors to acquire hard to find regional materials. Our master index of theses and dissertations, significantly enhanced and improved, was ready to reveal, and our legacy thesis and dissertation digitization project had just identified another 50 theses that were boxed and ready to send out for processing. Our full text online Virtual Landscapes of Texas database, with almost 60 new documents, was successfully moved to its forever home in the ScholarWorks repository: ***repositories.lib.utexas.edu/handle/2152/69304.***

Things were lining up nicely. That was in early March. Since then we have all been surfing a tidal wave of disruption, with yet unknown consequences. Certainly all our well-laid plans are up in smoke, significantly delayed at least. With other challenges resulting from a major library data migration, the regular work of moving materials, receiving packages, processing physical objects like books and journals, ordering new materials in physical formats, has all come to a grinding halt, creating backlogs that will all have to be dealt with when we are allowed back in the facilities. In effect, we will be almost a year behind on many routine workflows, at the same time that we will have to begin moving forward into the new structure for campus life, whatever that will be. We know we will be even more reliant on electronic resources, which will create hardships for our discipline and others. We know staff will return in phases, and with workspace capacities reduced, further delaying the catch-up process.

When the university reopens, with programs and procedures still subject to development, we will all be finding our way in a new landscape. Nevertheless, we remain dedicated to our traditional goals and values – the best services we can provide and the best collections and materials access we can afford. Certainly, the university faces serious fiscal decisions in the coming year or two. With the librarian retiring, a hiring freeze already in place and uncertainty about how those fiscal changes will affect the libraries, now more than ever your support for the Walter Library is essential to its future ability to continue as an integral part of the Jackson School experience. I hope this will be just a bump in the road, and that with time, someone with energy and imagination will come aboard, and, using the tools and collections we have developed over the past 35 years, will find new and better ways of serving the Jackson School with the information services it deserves for the 21st century.

I would be remiss if I did not acknowledge the many librarians and library staff I have worked with over the decades, who have done so much of the heavy lifting for my sometimes overambitious projects. A library is a community, not a room full of stuff. Thanks to one and all! This year's Guion Award winners, for extraordinary service to the Walter Library, are James Galloway, Walter Library unit manager, Colleen Lyon, head of scholarly communications, and Anne Morgan, iSchool GRA and excellent cataloger. Thanks to you all for your efforts! Student workers who graduated this year are Pamela Perez and Noelle Fremin. We wish them good luck and thank them for efforts.

So thank you for the memories, Jackson School family. Time to ride off into the sunset!

Dennis Trombatore, Librarian

This report was printed posthumously. Trombatore served for 35 years as the Head Librarian at the Walter Geology Library. Please see Trombatore's memorial on page 122.

Make Your Own Mars

In July 2020, the Mars 2020 mission set off for Jezero Crater.

Although it will be about another seven months before the mission rover touches down on the Red Planet, you can get to know the landing site ahead of time with a model of the crater that you can 3D-print yourself.

Researchers at The University of Texas at Austin created the model files by converting elevation data from the crater into a file that can be read by a 3D printer.

The file is available for download at ***www.jsg.utexas.edu/goudge/shared-data.***

The team behind the model consists of Jackson School of Geosciences Assistant Professor Tim Goudge; Professor John Kappelman, who holds appointments at the Jackson School and College of Liberal Arts; and Jackson School alumnus Michael Christoffersen.

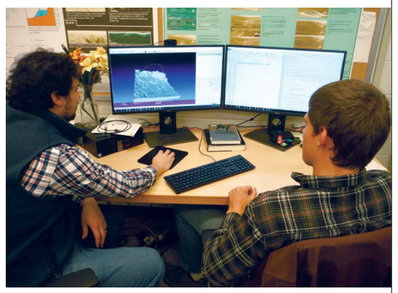
Christoffersen developed the open-source software for converting the elevation data while he was an undergraduate at the Jackson School. The crater's elevation data came from the Mars Reconnaissance Orbiter, a satellite orbiting the Red Planet.

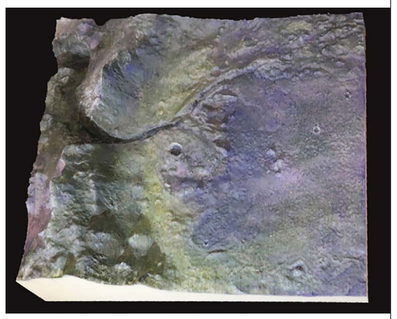
The model shows the amazing landscape that awaits the NASA rover. It includes sharp-peaked mountains that form the crater's rim, a valley carved by an ancient river, and the river delta's fan of sediments—which the Mars 2020 rover will sample for potential microfossils that would show that the Red Planet was home to life billions of years ago.

The model can be scaled up or down, but the standard size is about 8 by 7½ inches, about 100,000 times smaller than the area it represents on Mars. The landforms correspond to those on Mars, but the researchers increased their scaled-down height by five times so details would be easier to see and feel.

The model's size means it is right at home on a desk or bookshelf (which is where Goudge keeps his copy). But Goudge, who was the lead advocate for Jezero as the Mars 2020 landing site, said that he envisions the replica, first and foremost, as a teaching tool. In a world where space news is dominated by pictures, he said that the model could help people with visual impairments engage with Mars exploration.

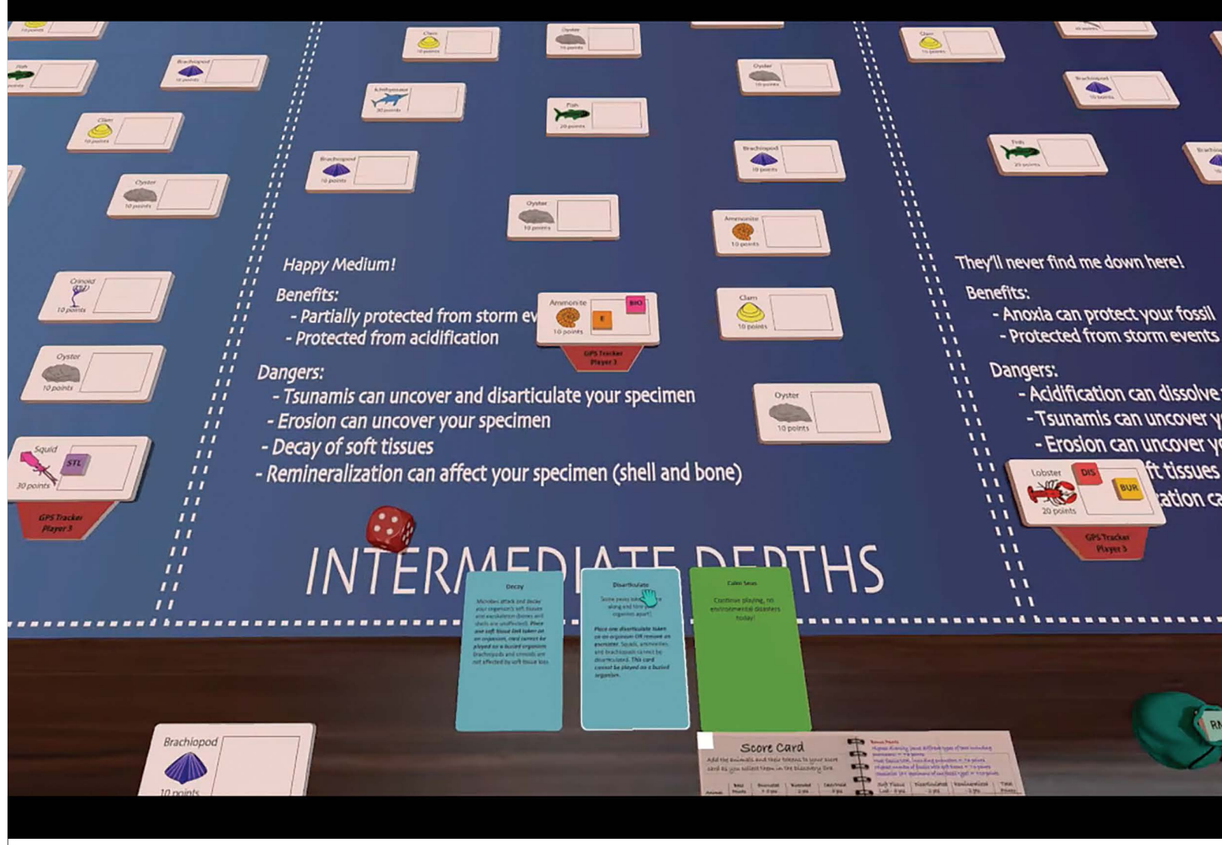
"Everybody can get something out of this, and it makes [research] more accessible to everyone," Goudge said.





TOP: JEZERO CRATER.
MIDDLE: TIM GOUDGE (LEFT) AND MICHAEL CHRISTOFFERSEN STUDY THE MODEL FILES.
BOTTOM: A PAINTED 3D-PRINTED MODEL OF JEZERO CRATER.

JEZERO: NASA. COMPUTER: TIM GOUDGE. MODEL: JOHN MAISANO.



Fossil Board Game Gets Online Edition

In 2019, Jackson School of Geosciences researchers debuted a board game all about fossilization. This summer, Rowan Martindale, an associate professor in the Jackson School's Department of Geological Sciences, created an online version that allows people to come together to play in a digital space—an apt innovation in a time of social distancing.

The game, called "Taphonomy: Dead and Fossilized," puts players in the shoes of time-travelling paleontologists to teach key concepts about how fossils form.

Martindale co-designed the game with Anna Weiss, who earned a Ph.D. from the Jackson School in 2019 and is now a postdoctoral researcher at the University of Belize. The game was originally envisioned as a tool to teach undergraduate students the notoriously difficult subject of taphonomy, or how dead things become fossils.

"Rather than learning abstract concepts from a lecture or textbook, the students learn what promotes or hinders fossilization as they encounter these factors through game play," Martindale said. "Overall, students seemed to really like it, and many preferred the game to a regular lab."

According to a 2019 study in the *Journal of Geoscience Education* that examined learning outcomes from the game, 71% of students thought the game helped them learn about fossilization, and 66% of students who played the game thought it was fun.

Outside the classroom, the game offers a fun and educational way for fossil fans and board game enthusiast alike to pass the time.

Print out a copy of the game at: ***http://ow.ly/M0tK50AKG72***

Or learn how to access it online at: ***http://ow.ly/3Ik950AKG1d***

TOP: THE VIRTUAL BOARD GAME.
MIDDLE: A FISH FOSSIL THAT INSPIRED A GAME PIECE.
BOTTOM: JACKSON SCHOOL PARTICIPANTS PLAYING THE BOARD GAME IN 2019.

GAME: JACKSON SCHOOL / TABLETOP SIMULATOR. FOSSIL & GROUP: ROWAN MARTINDALE.

Aspiring Doctors Get Dose of Geosciences

In July 2020, the Jackson School of Geosciences and Dell Medical School teamed up to teach high school students about the interplay between the planet and human health during a virtual summer camp.

Ninety students from high schools in Austin took part in the five-day camp, which combined a daily case study exercise with talks from health care and geosciences experts. The camp was based around three themes: pandemics, natural hazards and climate change.

"Hearing geosciences, I assumed earth, soil and all that, but after this camp, I definitely see that there's more to Earth … and how the Earth can actually impact the way we live," said camp participant Tomer Britva.

Jackson School Research Professor Sean Gulick gave a presentation about the 2010 Haiti Earthquake that killed more than 100,000 people. His talk covered a Rapid Response program research mission to Haiti that collected data on how the earthquake affected the coast and the seafloor, and how this information can help people prepare for future earthquakes.

Jackson School Professor Kerry Cook gave a presentation on the connection between climate change and health. A key point was how global warming affects health by increasing extreme events—such as heat waves, droughts and floods—and creating opportunities for certain infectious diseases to spread.

Jackson School Dean Claudia Mora left the group with some closing remarks on the final day of the camp. She said that solving challenges facing society will require collaboration across disciplines and encouraged students who do go on to careers in medicine to always keep the broader environment in mind.

"Never forget to look outside the body to consider the context," she said. "The body is breathing the air and drinking the water and living in the temperature and precipitation regime that is going to play a role in health."

In past years, the summer camp brought groups of students to The University of Texas at Austin campus for hands-on activities at Dell Medical School. Although the COVID-19 pandemic pushed the camp into the virtual setting, students remained highly engaged, said Lindsay Stephens, an operations coordinator in the Jackson School's Broader Impacts in Geoscience Education Research program, with most sticking with the program throughout the entire week.

Overall, the students left with a new understanding of how geosciences affects health. In response to the exit survey question "What was your biggest take-away from this course" almost every student mentioned a broadened understanding of how the two fields intersect.

"These past few days have made me realize the importance of geoscience, not only through its relationship with health sciences but also through its involvement with humanity," wrote camp participant Lamisa Mahmud. "Geoscience is more involved in our lives than many people realize, and it's about time that the topic is brought to the spotlight."

ABOVE: THE REAR FACADE OF DELL MEDICAL SCHOOL'S HEALTH LEARNING BUILDING.

OPPOSITE PAGE: MICHAEL PYRCZ PRESENTING A "GEOSTATS GUY" LECTURE ON YOUTUBE.

PHOTO: DELL MEDICAL SCHOOL.

PHOTO: JACKSON SCHOOL/ YOUTUBE.

Growing Audience for YouTube's Geostats Guy

Michael Pyrcz is an associate professor at the Jackson School of Geosciences and the Cockrell School of Engineering. On YouTube, he's better known as the Geostats Guy.

In June 2020, his channel, GeostatsGuy Lectures, passed the 5,000 subscriber mark after two years of uploads. At 5,750 subscribers and counting, the trend doesn't show any signs of stopping.

Pyrcz attributes the channel's success to the accessibility of his content.

"There are long-standing concepts in geostatistics that many struggle with, including kriging and variograms," Pyrcz said. "I have novel content that I think is very accessible."

Pyrcz's most popular video, "Geostatistics Course: Kriging," covers the process of interpolation to make spatial estimates and has more than 17,000 views. This is just one of more than 130 videos covering topics in data analytics, geostatistics, spatial data analytics and machine learning.

Pyrcz's video comments are full of viewers asking questions and extrapolating on the lecture. On the video about kriging, the top comment comes from subscriber Amit Joshi, who said, "I appreciate you posting such valuable lectures for public learning. Kudos to you."

Pyrcz started his YouTube channel at the request of his undergraduate students who wanted recorded lectures to study, though he quickly developed a goal of removing barriers to learning so he could help diversify his field.

"I realized that in this modern, connected world, anything I give my students will be eventually posted online," Pyrcz said. By posting it all into a YouTube channel, "I saw an opportunity to provide a single point for the products."

Since then, his audience has spread beyond undergraduates. According to Pyrcz's analysis, only about 20% of his subscribers are undergraduate students. About 60% are graduate students or early career professionals, and the remaining are mid- to late-career professionals. The channel also has international appeal, with about 70% of viewers outside the United States.

Other professors have even started using Pyrcz's videos in their courses. Glen Nwaila of the Economic Geology Research Institute at South Africa's University of the Witwatersrand's School of Geosciences is one such subscriber.

"Michael Pyrcz's videos are unique and one of the best I have ever come across so far in this subject of spatial/geostatistics," Nwaila said. "He explains complex concepts in a simplified form and also tries to break down why we do certain things. Michael's content provides a balanced approach of theory and application. I am grateful for what he has compiled."

'Switch On' is Energizing Audiences

When the COVID-19 pandemic shut down the theatrical run planned for "Switch On," a new energy documentary produced by Bureau of Economic Geology Director Scott Tinker, the film's team was undeterred. By April 2020, "Switch On" became available to stream for free on the website ***SwitchOn.org*** and soon after reached thousands of viewers.

"So far, 'Switch On' has been viewed over 4,000 times from audiences around the world," said Sophie Byard, the manager of the film's distribution efforts. "The audience has ranged from environmental science classes to major corporations and everything in between."

"Switch On" is the second film released by Switch Energy Alliance, a nonprofit organization created by Tinker. The first film, "Switch," explored energy sources across the world. "Switch On" focuses on areas of the world suffering from energy scarcity in an effort to continue its energy education mission.

The Switch Energy Alliance's digital plan allows group streaming so that companies, classes and organizations can host virtual "Switch On" watch parties to stay connected. During this pandemic, some viewers especially appreciated the film's message of hope and community.

"My students loved 'Switch On,'" said Karen Eckert, a professor of sustainability at Principia College. "The focus on what can be and is being done—often with few resources and in underserved populations—is really inspiring."

David Curtiss, the executive director at the American Association of Petroleum Geologists, agreed.

"[Switch On] reminded me why I chose and continue to be involved in this industry: Energy poverty is a big global problem, and I want to work to address problems like that," he said.

UT Energy Week Headed by EER Student

UT Energy Week is the premier student-run energy event at The University of Texas at Austin, bringing together energy experts in industry and academia with UT energy students for five days of panels and research presentations.

In 2020, then-graduate student Jennifer Sauer took the lead role in organizing the event, which took place Feb. 17-21.

Sauer graduated in spring 2020 with two master's degrees: an MBA from the McCombs School of Business and a master's from the Jackson School's Energy and Earth Resources (EER) program.

Managing and executing UT Energy Week was one of her key duties as the president of the Longhorn Energy Club.

"Our goal is to expose students to current trends and events in the energy industry," she said. "I was very happy with it."

The theme of this year's event was energy transition. It included talks and presentations on the science, law and geopolitics of shifting from carbon-based fuels to an energy system incorporating more renewable options.

Sauer said that members of the Longhorn Energy Club, which co-hosted the event with members of the *Texas Journal for Oil, Gas, and Energy Law*, selected the theme. But the theme was also right in line with her interests in sustainable development.

This is what first piqued Sauer's interest in the EER program, which enables students to pursue interdisciplinary studies in areas of geosciences, engineering, management, finance, economics, law and policy. She entered the program in 2017 thinking she would study water resources, but she soon shifted to the electricity industry.

"The energy system is changing so quickly, and electrification is a huge part of that," Sauer said. "And I find it so fascinating, the mechanics of the industry, policy, finance. I love it because it's very dynamic."

During her time in the EER program, she held internships at the Lower Colorado River Authority, Wood Mackenzie, Orsted, 7X Energy, and the National Renewable Energy Laboratory. Research she conducted at the lab on utility business models has been required reading in a Stanford Law School course on energy regulation and policy.

The opportunity to earn an MBA while earning an EER degree—a common track for EER students—helped Sauer learn more about business operations in general. She is now applying both degrees in the energy sector as a finance associate at Jupiter Power, an Austin-based energy startup dedicated to building utility-scale batteries.

And though she's focusing on renewable energy, Sauer said that she values the connections she made with classmates who have gone to work in other parts of the energy industry.

"I really treasure the relationships I developed with people in water, and oil and gas, or vehicles," she said. "In EER in general, you have an amazing opportunity to develop your network, and with energy changing so rapidly, that's very valuable."

EER Director Richard Chuchla said that Sauer's journey to the energy industry illustrates the opportunities offered by the program and bodes well for Sauer's energy career.

"In my four years as director of the EER program, I can't think of a student who better idealizes the multidisciplinary EER vision than Jenny," said Chuchla. "She came to us after several years in the health care industry with an undergraduate degree in neuroscience from Vanderbilt. She has left us with dual master's degrees, internships that exposed her to many aspects of energy and earth resources and exemplary leadership of the Longhorn Energy Club. She is more than ready for the dynamic world of energy."

FOREGROUND: JENNIFER SAUER. **BACKGROUND**: DANIEL SIMMONS (LEFT), ASSISTANT SECRETARY FOR THE OFFICE OF ENERGY EFFICIENCY AND RENEWABLE ENERGY, TALKS WITH UT ENERGY CLUB MEMBERS DURING UT ENERGY WEEK.

PHOTOS: JENNIFER SAUER.

Boy Scouts Explore Geosciences at Bureau

David Carr is a research scientist at the Bureau of Economic Geology. He is also a troop leader for Boy Scout Troop 31.

In February, Carr and Linda Ruiz McCall, a bureau information geologist, led the troop through an educational experience designed to help the scouts learn about careers in geoscience—and earn their geology merit badges.

The scouts participated in a number of hands-on activities. They explored fossils and minerals with volunteer and alumnus Allan Standen; took part in an interactive presentation with the bureau's new augmented reality sandbox with Research Scientist Associate Dallas Dunlap; and observed a demonstration of groundwater and surface-water interactions led by McCall. They also heard from Research Scientist Associate Vanessa Nuñez-López and Undergraduate Research Assistant Margaret Murakami, who spoke to the scouts about carbon capture and led them through a series of activities developed by the Gulf Coast Carbon Center.

Each of the presenters also spoke to the troop about careers in geology.

The troop ended their visit to the bureau with a trip to the newly renovated Austin Core Research Center, where center manager Nathan Ivicic explained the value of archiving core samples. Highlights of the troop's visit to the center include a walk through the research center entrance, which boasts a display of fossil dinosaur casts from the Jackson School Museum of Earth History, followed by an educational and energetic tour through the Stoneburner Family Rock Garden. The scouts left the bureau with a new understanding of careers in geology and the tools for understanding geological processes important to everyday life.

TOP: JACKSON SCHOOL ALUMNUS ALLAN STANDEN SHOWS ROCK AND MINERAL SAMPLES TO BOY SCOUTS. **BOTTOM:** RESEARCH SCIENTIST ASSOCIATE DALLAS DUNLAP SHOWS THE SCOUTS A 3D TOPOGRAPHIC MAP USING THE BUREAU'S NEW AUGMENTED REALITY SANDBOX.

PHOTOS: BUREAU OF ECONOMIC GEOLOGY.

GEO660

STAYING SAFE IN THE FIELD

ABOVE, LEFT: CHECKING A MAP ON A ROADSIDE STOP.
ABOVE, RIGHT: RETURNING FROM A CLIMB THROUGH THE MESOZOIC SECTION AT ALCOVA RESERVOIR, WYOMING.

ABOVE: 270-DEGREE PANORAMA OF ALCOVA RESERVOIR, WYOMING, WHERE (LEFT TO RIGHT) JUAN BENEVIDES, BRANDON COOPER, MARIO GONZALEZ AND PATRICK CASBEER TAKE A BREAK AFTER A SHORT CLIMB TO LOOK AT FRACTURE PATTERNS IN EOLIAN SANDSTONES AT ALCOVA ANTICLINE.

Last summer, the GEO 660 field camp started with a nasal swab.

Three days before heading out to the field, the course participants—eight students, three course instructors, a teaching assistant and an assistant instructor—emerged from a two-week quarantine to go to a University of Texas parking garage turned clinic for COVID-19 testing.

The tests all came back negative. The results kicked off a successful field camp that was reworked from top to bottom to keep students and instructors safe while providing a world-class geosciences education.

The Jackson School of Geosciences canceled its two other field courses, hydrogeology and marine geology and geophysics. That was the case for most university-led field courses across the country.

But GEO 660, the Jackson School's capstone field geology course, continued with a number of health and safety precautions in place.

PHOTOS (LEFT): MARK HELPER.

"It took a lot of hard work, went really well and came off without any problems," said field camp director Mark Helper, a distinguished senior lecturer in the Department of Geological Sciences. "We had a really strong group sensibility and great teamwork, with everybody looking after everybody else."

The course was reduced to three weeks instead of the usual six, with the class visiting field sites in New Mexico and Wyoming.

A major safety measure involved keeping the class size small. The course was limited to seniors who needed the course to graduate this year and a smaller than usual number of instructors. They included Professor and Department Chair Charles Kerans and Teaching Assistant Abdulah Eljalafi the first week, and Bureau of Economic Geology Research Scientist Peter Hennings for much of the remaining time. Helper and Assistant Instructor Kristina Butler taught for the entire period.

The class started each day with everyone completing a health form, noting their temperature and any potential COVID-19 symptoms. Initially, masks were required at all times. With prolonged isolation and no one exhibiting symptoms, that requirement was gradually loosened, first for fieldwork, where social distancing could be practiced, and later at camp. Gas stops and bathroom breaks on travel days posed the greatest risks, so masks, social distancing and a host of other protocols remained in place during those times.

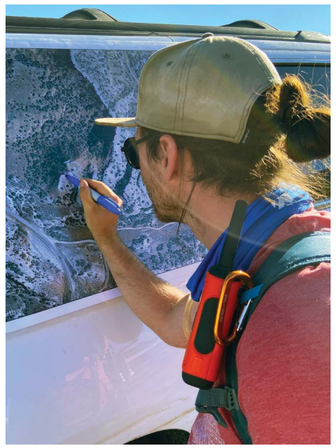
The group traveled in two Suburbans, a 12-passenger van and a pickup to maintain social distancing. Camping sites and project areas were selected to be as remote as possible to avoid encountering others. With nearly all public campgrounds closed during the summer, this was not

BELOW: WITH AN IPAD AND STRIKE-AND-DIP APP, MARIO GONZALEZ MAPS BEDDING ORIENTATIONS FOR THE ALCOVA ANTICLINE MAPPING PROJECT.

PHOTOS (TOP AND RIGHT): SHAINA GOODWIN.

ABOVE: THE FIRST DAY OF CAMP AT AN OVERLOOK OF TEPEE MOUND ALONG THE WESTERN ESCARPMENT OF THE SACRAMENTO MOUNTAINS, NEW MEXICO. **RIGHT:** THAN NGUYEN PONDERS COMPLEX VOLCANIC STRATIGRAPHY IN THE RED RIVER GORGE AT RIO GRANDE DEL NORTE NATIONAL MONUMENT, NEW MEXICO.

ABOVE: THAN NGUYEN RELAXES AT CAMP AMIDST CROSS-BEDDED SANDSTONE, CENTRAL WYOMING. **RIGHT:** BRANDON COOPER TAKES A TURN ANNOTATING ALCOVA ANTICLINE COMPLEXITIES ON A HIGH-RESOLUTION SATELLITE IMAGE. **BELOW:** BACKYARD CAMPING ALONG THE BIGHORN RIVER, THERMOPOLIS, WYOMING.



just the safest option but often the only one. For the New Mexico portion of the class, the group got lucky and at the last minute secured relatively remote group sites with shelters and bathrooms in the Lincoln National Forest near Cloudcroft and at a campground near Questa. In central and northern Wyoming, camping was done "expeditionary style," without access to any facilities.

"I think more than any previous year, the students really got an opportunity to go into the field feeling really equipped for the camping component," said Butler, who led a number of how-to meetings over Zoom during the weeks leading up to the course. "A lot of them came out saying 'I want to go on backpacking trips with my friends,' or 'I feel like I can do field work in remote areas.'"

PHOTOS: MARIO GONZALEZ (TOP RIGHT), SHAINA GOODWIN (MIDDLE LEFT, BOTTOM), MARK HELPER (TOP LEFT, MIDDLE LEFT).

TOP: MAPPING PARTNERS EMILY REEVES (LEFT) AND MARK LAWRENCE (RIGHT), GATHERING DATA AT ALCOVA ANTICLINE. **LEFT:** EMILY REEVES TAKES IN THE VIEW LOOKING WEST FROM THE DEADMAN BRANCH OF ALAMO CANYON, AT THE BEGINNING OF THE LAKE VALLEY FORMATION. **BOTTOM:** MEASURING SECTION IN THE LAKE VALLEY FORMATION, SACRAMENTO MOUNTAINS, NEW MEXICO.

It's not uncommon for GEO 660 courses to enroll 30 or more students. This year's small class size allowed for more personalized instruction, said student Mario Gonzalez. The general topics covered were the same as any other field camp, said Helper. The students measured sections, took field measurements, interpreted field relationships and constructed cross sections and maps — they just did it on a tighter, more condensed schedule.

According to Gonzalez, by the time the course was finished, he had seen an example of just about everything covered in his earlier geosciences courses.

"It was crazy because, at one point or another, I ended up using something that I learned in every single one of my classes," he said.

The small course size and remote field settings had another perk: Everyone came together to cook dinner each night, taking direction from Butler, who trained as a pastry chef in France before starting graduate school.

Although COVID-19 made the 2020 field camp unlike any other, student Brandon Cooper said that GEO 660 was the perfect ending to his undergraduate studies at the Jackson School and left him with a better sense of what it means to be a geologist.

"We really got to see what a geologist does," Cooper said. "When I tell people I study geology at UT, I tell them it's a lot more complex than just studying rocks. And now it's a lot easier for me to explain what a geologist does."

PHOTOS: MARK HELPER.

Spring-Fed Science in West Texas

Driving along I-10 through the vast, arid region of West Texas, the last thing one would expect to find is a large pool of crystal clear, spring-fed water. But that is exactly what tourists and locals alike have enjoyed at Balmorhea State Park for generations, located just a few miles off the interstate between Fort Stockton and Van Horn at the base of the Davis Mountains.

Officially known as San Solomon Springs, this desert oasis not only serves as an important recreational area and source of water for local communities and agriculture, it is also home to a wide array of wildlife, including two small, endangered desert fishes: the Pecos gambusia and the Comanche Springs pupfish.

For the past two years, researchers at the Bureau of Economic Geology have been studying this spring-fed pool, along with other nearby freshwater springs, in order to develop a comprehensive hydrogeologic model for the region. By monitoring precipitation along with stream and groundwater flow in the nearby Davis Mountains and looking for associated changes in spring flow and chemistry, researchers hope to improve upon previous models of the spring system.

In July 2020, Jackson School of Geosciences Professor Bayani Cardenas volunteered to help out by diving to the bottom of the spring-fed pool to replace a pressure-temperature-conductivity sensor that regularly collects readings from the spring. Meanwhile, on the surface, Jackson School doctoral student and bureau technician Tyson McKinney collected samples of water emanating from what is believed to be the main spring vent thanks to the placement of a sampling hose by Cardenas during his dive.

Geochemical analyses of these samples, along with data collected from the sensor, will help researchers at the bureau better understand how local and regional hydrologic events affect this important spring system.

Tyson McKinney
Doctoral Candidate

ABOVE: BAYANI CARDENAS (BACKGROUND) GUIDES TYSON MCKINNEY TO THE SPRING VENT TO SHOW THE PLACEMENT OF THE SAMPLING HOSE AND THE SENSOR HOUSING.

PHOTO: MAYUMI CARDENAS.

PHOTOS: JACKSON SCHOOL.

TOP: A GROUP "HOOK EM" WITH "THUMPER," A VIBROSEIS TRUCK.
MIDDLE: DOCTORAL CANDIDATE ANDREW GASE DIRECTS "THUMPER" INTO POSITION.
BOTTOM: RESEARCH PROFESSOR SEAN GULICK (BOTTOM LEFT) AND UNDERGRADUATE REEM ALOMAR (BOTTOM RIGHT) DEPLOY SEISMIC EQUIPMENT WHILE OTHERS LOOK ON.

Vibroseis Experiment at the Texas Observatory

In February 2020, the Texas Geophysical Society, The University of Texas at Austin's student chapter of the Society of Exploration Geophysicists, led a unique seismic survey in the heart of the Texas Hill Country. The experiment took place in an open field at the White Family Outdoor Learning Center, which is part of the Jackson School of Geosciences' Texas Observatory, and adds to the breadth of research conducted at the property since it was donated to the school by the White family.

Seismic data is a staple of the geophysicist's toolbox, and while many students learn processing and interpretation techniques, few get the opportunity to participate in the data acquisition. With over 20 undergraduate and graduate participants, the experiment allowed students to gain hands-on training deploying seismic instruments and contributing to the collection of meaningful images to better understand the subsurface geology at the property. The survey was particularly unique because the seismic waves were generated by "Thumper," a vibroseis truck with a hydraulically controlled platform to shake the ground at a range of frequencies. Thanks to UT's Natural Hazards Engineering Research Infrastructure program, which operates Thumper, the students were able to see the truck in action and feel the vibrations traveling beneath their feet—an immersive experience that cannot be replicated in the classroom.

Guided by Associate Professor Kyle Spikes, Research Professor Sean Gulick and Research Engineering Scientist Associate Thomas Hess, students took charge and planted geophones into the ground, laid cables connecting the geophones into seismometers, surveyed the precise location of the instruments, and guided Thumper to each shot location.

Overall, operations went smoothly and the experiment was a great success! Post-collection processing of the 200 meter-long 2D seismic profile has provided the first subsurface image along the property. Preliminary results show the interaction of faults, fluids, and possible cave structures, which may lead to new scientific insights about the Edwards-Trinity Aquifer system. For the students, getting their hands dirty and vibing with Thumper was an extraordinary experience they will never forget.

Brandon Shuck
Doctoral Candidate

Field Log: Weathering an Antarctic Snowstorm

In January 2020, UTIG polar researchers Dillon Buhl, Anja Rutishauser and Natalie Wolfenbarger joined colleagues in West Antarctica to conduct vital surveys of one of the most unstable glaciers on Earth. The team is part of LIONESS, an international collaboration between The University of Texas at Austin, Montana State University and the Korea Polar Research Institute which aims to resolve unanswered questions about the sprawling Thwaites Glacier system.

In the third post of her four-part field journal, Rutishauser continues her tale of drama and adventure at the far reaches of the Earth.

To read her story from the beginning, visit: ***ig.utexas.edu/tag/lioness-blog***

Although the rescue mission had set us back weeks, our team was optimistic, and we looked forward to a tight but manageable two weeks to finish our scientific surveys.

However, as other parts of Antarctica scorched under record-breaking temperatures, conditions at our camp went from bad to worse. Thick clouds brought snow, which quickly turned to blizzards.

That very first day, I piled up chunks of snow on the sides of my tent in case things turned stormy. Little did I know keeping the tent in place was the least of my worries! At night, the wind howled and snow battered my tent. I admit it was nerve-racking, and I found myself wondering in what condition my tent would be the next morning and how long it would take to dig my way out!

Earplugs, sleeping mask and a warm sleeping bag can do wonders in the field, and after a while, the wind and snow became almost soothing. The snow and bad weather continued for eight days. As one day merged into another, we found our patience severely tested, fighting boredom as much as we fought the snow.

To stay busy, each day we planned the next day's survey flight in the hope that morning would bring better conditions. The rest of the day was spent in the camp's mess tent reading, knitting socks and even watching the occasional movie.

In fact, once we got used to it, life at our camp was great! Being surrounded by nothing but snow and ice is an indescribable but very special feeling.

One of the advantages of being grounded is having plenty of time to cook! Some delicious meals we prepared included lamb chops, all kinds of pasta, Bolognese, pizza (yes, you can cook a pizza in a frying pan), steak and burgers.

Anja Rutishauser
Postdoctoral Fellow, University of Texas Institute for Geophysics

CLOCKWISE:
1. (LEFT TO RIGHT) UTIG RESEARCHERS DILLON BUHL, LUCAS BEEM, NATALIE WOLFENBARGER AND ANJA RUSTIHAUSER ON THWAITES GLACIER, WEST ANTARCTICA, FEBRUARY 2020.
2. BEEM AND RUSTIHAUSER FLIGHT PLANNING IN THE MESS TENT.
3. SUNNY WEATHER AND BLUE SKIES ON THE FIRST DAY OF CAMP.
4. SNOW COVERED TENTS.

PHOTOS: ANJA RUTISHAUSER.

Hydro in the Wild West

At The University of Texas at Austin's McDonald Observatory, high up in the Davis Mountains of West Texas, a team of Jackson Schoolers led by professors Clark Wilson and Daniella Rempe has been studying groundwater. Since 2018, they have been building a network of instruments—a mountaintop hydrologic observatory of sorts—to monitor water storage in the region's volcanic soils and rocks. But their work has a slight twist: They are employing a unique geophysical tool called a superconducting gravity meter.

During 10 trips spanning the past two years, Wilson, Rempe and their team have outfitted a mountaintop at McDonald Observatory with a variety of hydrologic tools. Among them are soil moisture probes, piezometers, boreholes, a meteorological station, and notably a superconducting gravity meter. The gravity meter, which they deployed in September 2019, is one of only 75 such sensors in the world. It measures how moving environmental masses, such as water and atmospheric gases, ever so slightly change Earth's gravity.

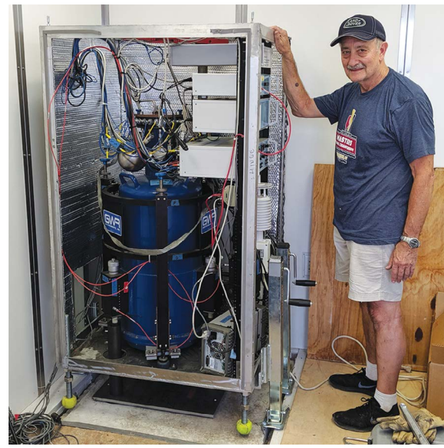
Wilson, Rempe and their team are applying these data to problems in both hydrology and in geodesy. Their hydrologic objective is to monitor and model components of the water cycle, a task that is complicated by the heterogeneous volcanic subsurface. Preliminary data indicate that during the recent dry season, McDonald lost approximately a 20-centimeter layer of groundwater.

The team is also conducting related geodetic studies with these same data sets. For a multiyear investigation funded by the National Geospatial-Intelligence Agency (NGA), they are developing methods to predict how water storage change affects absolute gravity surveys. They are also examining whether groundwater changes cause site deformations at McDonald, as a contributing partner in NASA's new McDonald Geodetic Observatory.

No field work is complete without a few unplanned adventures. In September 2019, the instruments survived multiple nearby lightning strikes. More recently, in late July 2020, the gravimeter stopped recording data. The team dispatched graduate student Chris Linick for an emergency repair mission to McDonald. He spent three days alone in the small gravimeter enclosure—a challenging task on its own—but emerged victorious after replacing multiple components. Gravimeter data are now flowing freely once more.

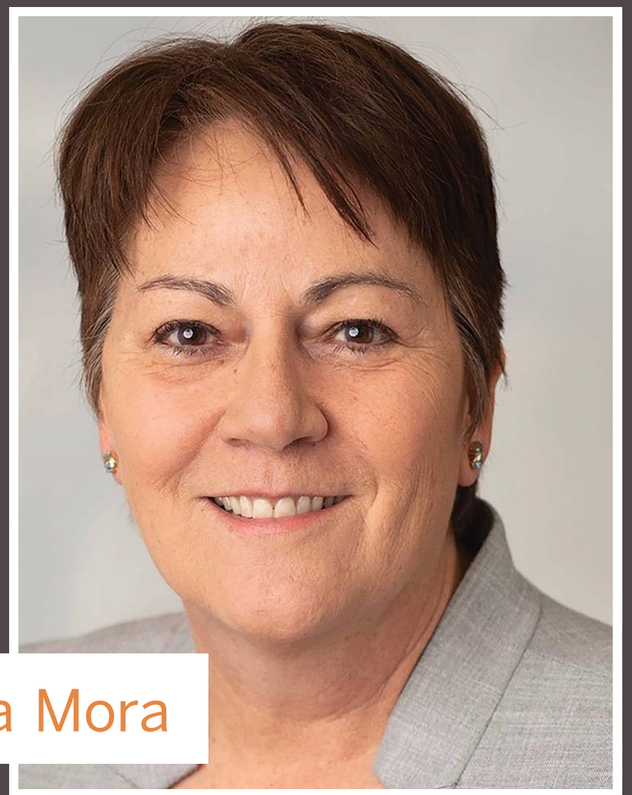
This work is funded by grants from NGA and UT's Office of the Vice President for Research, in cooperation with McDonald Observatory and NASA. Talented current and former JSGers Logan Schmidt, Mariel Nelson, Brandon Minton and Jesse Hahm have made major contributions to the project.

Chris Linick
Doctoral Candidate



CLOCKWISE:
1. (LEFT TO RIGHT) ZACH MUNGIA, COLT KERNAN, LOGAN SCHMIDT, AND BRANDON MINTON POSE AFTER A SUCCESSFUL DRILLING CAMPAIGN THAT PRODUCED TWO BOREHOLES AND MULTIPLE CORE SAMPLES.
2. GRADUATE STUDENT CHRIS LINICK CHECKS ON THE GRAVIMETER FROM A "REMOTE OFFICE" IN WEST TEXAS.
3. PROFESSOR CLARK WILSON STANDS NEXT TO THE SUPERCONDUCTING GRAVIMETER.

PHOTOS: CHRIS LINICK.



Claudia Mora

By Monica Kortsha

In February 2020, Claudia Mora became the dean of the Jackson School of Geosciences. Mora has had a varied career in geosciences—serving as a division leader at Los Alamos National Laboratory and as the head of the geology department at the University of Tennessee, Knoxville. As dean, she envisions an environment where students can cultivate skills no matter where their careers take them.

When Claudia Mora joined the Jackson School of Geosciences in spring 2020, she hit the ground running. The coronavirus pandemic closed The University of Texas at Austin campus during her second month on the job. The situation meant guiding the Jackson School through the online transition.

It was a hectic start. But Mora has had plenty of experience working in high-stakes situations. Before accepting the position as dean at the Jackson School, she served as the deputy division leader of Los Alamos National Laboratory's Chemistry Division, where a key scientific focus is detecting nuclear weapons material as it's moved around the globe.

PHOTO: CLAUDIA MORA.

But what brought Mora to the Jackson School in the first place was its breadth and depth of research and the education it provides students at all stages. A former department head in geology at the University of Tennessee, Mora has experience in both academic and independent research environments. This complements the unique structure of the Jackson School, which blends academics with research groups across three distinct research units.

"Joining this community is a tremendous opportunity," she said. "The educational experiences our students receive are excellent, the research is world-class, and the collective impact of the community is remarkable."

Throughout her career, Mora has been keenly aware of the diversity of pathways offered by the geosciences. She said her guiding principle has been to build up the skills that would provide different options—and then keep an eye out for opportunities to leverage those skills.

"It's important to be resilient in your career and life, and to be able to adapt to changes that you may—or may not—anticipate," Mora said. "Because big changes happen, and the world doesn't stop for you to catch up. So, being able to learn new things on the fly and to conceive how to use your skills towards a new problem or in a new position are very important."

Mora said her interest in geosciences started with a field-mapping trip with her older sister, who studied geosciences and went on to have a career in the oil and gas industry.

Mora was in her freshman year at The University of New Mexico, when the pair went mapping on Canjilon Hill, just north of Albuquerque. Mora said she left the field with a new perspective on a familiar landscape.

"I thought it was really cool that you could actually look at the landscape and understand it," she said.

The experience inspired her to take a geology class, and from there, she was hooked. As an undergraduate, she conducted research on the geochemistry of the Grants mineral belt, the main source of uranium in New Mexico. Mora continued geochemistry research into graduate school, investigating geochemical processes in metamorphic settings.

She earned a master's at Rice University in 1983, where she studied the metamorphic petrology of the Oaxacan Complex. At the University of Wisconsin-Madison, her doctoral research focused on fluid-rock interaction from a field site at the edge of the Idaho Batholic.

Even when pursuing her graduate research, Mora kept the door open to other opportunities. While at Rice, she took a summer job with Gulf Oil, where she wrote descriptions of offshore basins based on Portuguese documents from Petrobras, a Brazilian oil company. Mora's knowledge of Spanish, a similar language, enabled her to carry out the translation work and the scientific synthesis.

As a doctoral student, Mora had an adviser who recommended that each student have "three tricks"—three distinct skills that students could leverage during their careers. So in addition to her primary work on stable isotope analysis, Mora took extra classes in crystallography and petrology. She also earned a minor in chemistry, which fulfilled a university requirement that doctoral students have a minor field of study.

MORA WITH LONGHORN IN 2019, ONE YEAR BEFORE SHE WOULD JOIN THE UNIVERISTY OF TEXAS AT AUSTIN.

When Mora earned her Ph.D. in 1988, being a woman in geosciences—let alone a Latina—was rare.

The first job Mora landed was as a visiting professor through a program dedicated for minority researchers. But Mora found that it created barriers by placing researchers on a nontenure career tract for a number of years. While Mora is grateful that the program provided a means for her to improve her teaching and to secure her first research grant from the National Science Foundation, she ended up leaving as soon as she could, accepting a position as an assistant professor in the geology department at the University of Tennessee in 1989.

Mora said that her experience has made her work vigilantly to ensure that diversity programs help people in the long run.

"I've been careful with programs ever since to make sure that people are actually being helped," Mora said.

It's a perspective that Mora is putting to work as the Jackson School revamps its own diversity efforts.

At Tennessee, Mora was the first woman and first minority on the geology faculty. A few years into the job, she would be the first faculty member on the tenure track to give birth. She was also the university's first stable isotope geochemist.

"That's probably the best thing that ever happened to me, frankly, because I had a lot of freedom to use isotopes in any way I could get funded," Mora said.

PHOTO: CLAUDIA MORA.

CLAUDIA MORA AND DAUGHTER, ELIANA, IN 2007 AT THE VALLES CALDERA, NEW MEXICO.

Stable isotope analysis is a technique that can detect chemical signatures across a number of materials and environments. Although she had worked alone up until that point, the technique became a means of collaborating with experts in a number of other geosciences.

Her first collaborative project investigated oxygen and carbon in paleosols with her colleague Steven Driese. It was among the first studies to use stable isotopes to investigate ancient levels of carbon dioxide in the atmosphere, with the results showing a large drawdown of carbon dioxide associated with the explosion of plant life that occurred between 300 million and 400 million years ago.

This work set the stage for other studies that applied Mora's stable isotope analysis to a number of other areas. One of the most notable involved using oxygen isotopes preserved in tree rings to create a proxy record for hurricanes, which generate rainstorms that are unusually depleted of heavy oxygen isotopes.

Years of collaboration have created a unique research record that spans geoscience disciplines.

"I'm kind of proud, in an odd sort of way, that my three highest cited papers are in three fundamentally different areas: the paleosol research, dendroclimatology, and fluid rock interaction at high temperature," Mora said.

Mora rose through the ranks at the University of Tennessee, and in 2002, 13 years after she arrived, she became head of the geology department.

But Mora's career track changed in 2007, when her husband accepted a job at Los Alamos National Laboratory. Back in New Mexico, she had to revise her research focus and had to build a new career. During this time, she did professional service on the National Science Foundation Geosciences Advisory Committee, National Research Council Board on Earth Sciences and Resources, and as a councilor for the Geological Society of America.

"I discovered, as I served as department head or worked on professional panels, that I liked to create environments for science, to try to direct people towards collaborations in science that would do good things," Mora said. "I didn't have to be the one to do the science. I didn't need to have the credit for the science being done. I just wanted to facilitate good science being done."

Mora turned her focus to cultivating research environments where science could thrive. And in 2010, she became the group leader of the Los Alamos Earth Observation Group, a broad group with projects that spanned from fracture systems, to monitoring tree mortality, to measuring melting permafrost.

In 2016, Mora served as the president of the Geological Society of America. And after seven years leading the Earth Observation Group, Mora became the deputy division leader of the Los Alamos Chemistry Division—her most recent position before the Jackson School.

Sharon Mosher, the Jackson School's former dean, said that Mora's broad experience at research institutions and geoscience organizations will serve the Jackson School well.

"Claudia was a great choice for dean of the Jackson School," she said. "With her experience holding leadership roles both in academia and at a national lab, she has the experience and skills to take the Jackson School to new heights."

Research at Los Alamos is centered on mission-driven science, with projects working toward a specific goal, some focusing on long-term challenges and others on a short-term time frame. Mora is interested in cultivating a similar mindset at the Jackson School.

"It really does jive with the Jackson School's mission statement, which says that we conduct research and discover knowledge for the benefit of society," Mora said. "Applied-, mission-driven or mission-inspired science can coexist with basic research."

At the same time, she wants students at the Jackson School to hone their skills that will serve them on that mission—wherever it takes them. Mora's doctoral adviser talked about "three tricks." But Mora's preferred analogy is collecting bricks, with each brick being a skill or experience cultivated during graduate school or through a professional career. In her mind, it's better to use them to build roads to new places than wall yourself in.

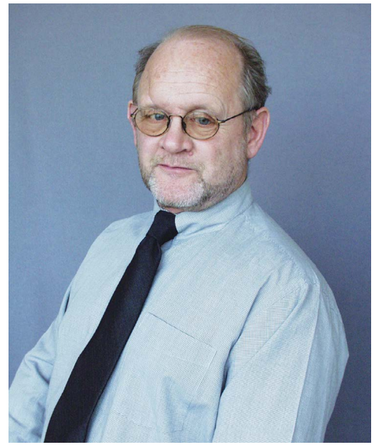
"When the bricks fall down and go all over the place, then the question is, can you then find a path forward," Mora said. "Can you lay them out in way that gets you to a new place?"

PHOTO: CLAUDIA MORA.

Ronald Steel

Professor Emeritus

By Kristin Phillips



RONALD STEEL

A former chair of the Department of Geological Sciences, Ronald Steel has built a career studying sedimentology and stratigraphy at field sites around the world. Now retired and with professor emeritus status, he has no plans of stopping anytime soon.

In 2013, after spending 41 years researching sedimentology and stratigraphy around the globe, Jackson School of Geosciences Professor Ronald Steel found the perfect field site: a spot five hours' west of Neuquén, Argentina, on the eastern flank of the Andes. There, he and his students have traced the Jurassic rivers that flowed out onto an ancient continental margin and moved sediment into a marine delta system that was part of the evolving South American Pacific.

"This is one of about three places in the world where you can really 'walk out' across the ancient continental margin—the shelf, the continental slope and the deep-water submarine fans—because it is now uplifted well above the water," said Steel.

Steel joined the Jackson School in 2003, holding the Davis Centennial Chair in Petroleum Geology, and was the chair of the Department of Geological Sciences from 2011 to 2015. In June 2020, he retired and now has emeritus status.

But that does not mean that his work will stop. Far from it.

"One of the things that happens when you begin to write papers, you discover that you are missing information," said Steel. "So, we are returning soon to this really beautiful area."

Steel grew up in Glasgow, Scotland, but spent his summers in his family's old stone cottage on the Isle of Raasay; his grandfather belonged to the McLeod clan of that island. There, Steel would wander around, meeting students and professors and wonder what each of them was doing with a hammer and a notebook and a map.

By the time he started graduate school at the University of Glasgow in 1972, he was sewing together all of the bits and pieces of nonmarine Triassic rifted basins of northwest Britain into a more coherent paleo-geographic map by mapping the red-colored rocks on the Hebridean islands of western Scotland.

Steel's early academic career was spent in Norway. Soon after finishing his doctorate—when oil exploration was just beginning in the North Sea—he got a position at the University of Bergen to train students in sedimentary geology. He also spent nine years working for the oil company Norsk Hydro.

"It was like heaven. It was the only way for me to get my hands on the new exciting marine geology of offshore Norway: the well, core and seismic data," said Steel.

He returned to academia in 1990, first returning to the University of Bergen and then the University of Wyoming.

Steel's research focused on how continental shelves arise globally and in the sequence stratigraphy made by sea level change, tectonics and climate over time. His expertise helped discover pockets where sand accumulated at the bottom of continental slopes, areas where ancient rivers dropped sediments that became the biggest reservoirs of oil and gas in the world. He also has mapped the tidal activity etched onto the marine rocks from the Western Interior Seaway, the shallow sea that stretched from Texas to Canada during the Cretaceous. During the past 10 years, he worked on larger-scale continental margins in the Jurassic Pacific margin of western Argentina, the South China Sea Neogene margin, and the Caribbean Orinoco margin of eastern Venezuela and the island of Trinidad.

Throughout his career, Steel's research output has been exceptionally high—260 papers and 11 books—and impactful, with nearly 18,000 citations and eight best paper or poster awards from various societies. In 2016, he received the Twenhofel Medal for outstanding contributions to sedimentary geology from the Society for Sedimentary Geology.

"Ron's research covers the entire spectrum of siliciclastic sedimentology," said Jackson School inaugural dean William Fisher, a fellow Twenhofel Medal winner and former department chair. "In recent years, Steel and his associates have significantly advanced our understanding of shelf-edge systems and their role in delivery of sediments to the deep basin. The Jackson School was most fortunate in recruiting this affable North Atlantic Scot by way of Wyoming and having him as a friend, colleague and associate."

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PHOTO: JACKSON SCHOOL.

Ken Wisian

Associate Director: Environmental Division

By Anton Caputo

Ken Wisian is a retired general, a geophysics expert and—most recently—the associate director of the Environmental Division at the Bureau of Economic Geology. From natural disaster preparedness to geothermal energy, he sees big opportunities for applying bureau expertise to some of the world's most pressing issues.

KEN WISIAN

Succinctly summing up Ken Wisian is not a simple task. By his own admission he's lived something of a split life. He spent 33 years in the U.S. Air Force, flying as a navigator and retiring as a major general. Along the way, he carved out a career as a scientist, earning a Ph.D. from Southern Methodist University in geophysics, serving as deputy director of the Texas General Land Office and playing leading roles in major initiatives in disaster analytics and geothermal energy.

At the moment, Wisian describes himself as a "happy nerd" who is thrilled to have joined the Bureau of Economic Geology as the associate director of the Environmental Division.

Wisian started his new position in May 2020, replacing Michael Young, who is returning to the role of senior research scientist. He moved to the bureau from the The University of Texas at Austin Cockrell School of Engineering's Center for Space Research, where he was executive director of the Disaster Research Program. Disaster research is one of Wisian's main fields of study along with geothermal energy. But he said what really drew him to the bureau was the impressive breadth of important issues that the environmental division tackles.

"When you see what the Environmental Division of the bureau is in—carbon capture, water resources modeling, induced seismicity—these are all hot topics, and they're doing tremendous public good," he said. "This is very exciting to me."

In his new role, Wisian sees his military experience helping him bring together interdisciplinary teams to tackle big problems. That's the kind of organizational focus that makes Wisian a natural for the new position, said bureau Director Scott Tinker.

"He brings a terrific sense of organization and leadership, a strong background in science, with a current personal focus on geothermal, and broadens our administrative skill sets," Tinker said. "As a bonus, he has a great sense of humor!"

The last comment is a nod to Wisian's personality, which Wisian readily admits might run counter to what people expect when they first meet him.

"People assume that, being a retired general, I'm a fire-breathing dragon," he said with a laugh. "I'm actually a pretty easy-going guy."

Wisian said he believes his specialties fit in perfectly with the bureau's work. The bureau, for instance, already plays a leading role in several areas of science that help prepare for and respond to disasters. Bureau scientists are particularly active in monitoring coastal ecosystems and communities, collecting data vital for understanding the impact of hurricanes and floods.

Bureau Senior Research Scientist Jeff Paine first met Wisian while working on these issues, when Wisian was deputy director at the Texas General Land Office. Paine had a positive first impression and said he's not surprised that Wisian has hit the ground running at the bureau.

"I was impressed with his grasp of major coastal issues facing Texas, his eagerness to listen and gather information, and his perceptive suggestions for areas of critical research need," Paine said. "In his short time at the bureau, he has already demonstrated his managerial gifts to solicit input, offer constructive observations, clear administrative hurdles and enthusiastically encourage those with whom he works. We look forward to helping him expand the bureau's research breadth."

Wisian sees a lot of "low hanging fruit" for the bureau when it comes to disasters, like creating better flooding predictions on the Texas coast during hurricanes. Ultimately, he wants to help create a disaster analytics research center, a project he is working on with Clint Dawson at UT's Oden Institute for Computational Engineering and Sciences. Wisian gained significant experience in disaster zones as a first responder, including during Hurricane Katrina and the space shuttle Columbia disaster. He said that although collecting data is crucial, there's a gap when it comes to making use of that data.

"There are petabytes of data generated and collected during the disaster, but we use maybe 1% of the information," he said. "Our goal is not to actually be the data repository but to make use of that data, applying modern big data tools, machine learning and

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PHOTO: KEN WISIAN.

Lisa Boucher
Director of the Non-Vertebrate Paleontology Laboratory

More than 4 million specimens and counting fill the drawers, shelves and storage warehouse space at the Jackson School of Geosciences' Non-Vertebrate Paleontology Laboratory (NPL). But only about 20% of the specimens have been officially cataloged.

As the new director of the NPL, Lisa Boucher is leading the effort to record the laboratory's immense holdings—which include fossil invertebrates and plants, microfossils, as well as rock and mineral samples—while compiling new specimens that the laboratory continues to take in.

A curatorial assistant at the lab since 2017, Boucher has plenty of experience working with volunteers, students and staff to keep the collections organized as they continue to grow.

"It's a large-scale effort to maintain the collection, image the specimens and document their associated data," said Boucher, a paleobotanist and former lecturer at The University of Texas at Austin and associate professor at the University of Nebraska at Omaha.

Boucher became the director of the NPL in November 2019, filling the spot left by former director Ann Molineux, who passed away in February 2018.

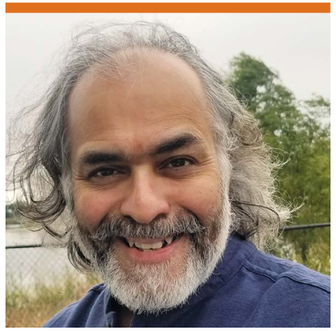
Among the latest incoming collections are thousands of thin sections and hand samples from Jackson School Professors Earle McBride and the late Bob Folk, as well as cave samples collected by Jackson School Professor Jay Banner and his research group.

The new specimens underscore a constant need at the NPL: adequate, climate-controlled space to store them all.

Boucher said a major victory for fossil storage was achieved in December 2019 with the opening of the NPL's Ann Molineux Paleontology Laboratory, a climate-controlled space adjacent to the other NPL collections. Thousands of specimens have since moved into the space. Boucher said she is working to obtain funds for cabinets that will allow more specimens to make the move.

While running the NPL, Boucher is also continuing her own research on Cretaceous plants, focusing on how flowering plants came to be the most diverse and abundant species across different environments on Earth.

by Monica Kortsha



Dev Niyogi
Professor

Growing up, Dev Niyogi had no idea how much his childhood in India would affect his future career path. As a child interested in math and science, he expected to join many of his friends in computer engineering. However, after getting his undergraduate degree in engineering, Niyogi went on to earn a doctorate in atmospheric science from North Carolina State University in 2000.

"I was always fascinated by the lively motion in the atmosphere. I grew up in monsoon region, where I've seen heavy rains, experienced cyclones, experienced floods. It was normal life," Niyogi said. "It was only later that I started finding ways to transform this thinking, that maybe things don't have to be the way they are."

This fall, Niyogi joined the Jackson School of Geosciences faculty. He holds the John E. "Brick" Elliott Centennial Endowed Professorship in Geological Sciences. He is also part of the faculty at The University of Texas at Austin Cockrell School of Engineering and a theme organizing committee member of Planet Texas 2050, a UT Bridging Barriers initiative that seeks to apply research on the environmental challenges facing Texas to the world.

Before joining UT, he was a professor at Purdue University for 15 years. During most of that time, he also served as the state climatologist of Indiana.

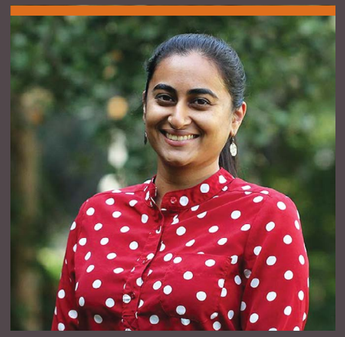
Niyogi's doctoral research was among the first to introduce carbon dioxide and land use feedbacks into weather forecast models. Shortly after earning his doctorate, he participated in a workshop at the Aspen Institute on the concept of how land affects climate. This resulted in a seminal research paper that led to the addition of land use changes into climate models.

Recently, Niyogi's research has focused on the complex relationship between human decisions, weather and regional climate. An example is the tendency of thunderstorms to break up into "beltway storms" as they approach a city so that the places around its periphery experience rainfall and potential damage. Niyogi said that understanding the links between cities, landscape, human decisions and climatic extremes can help improve the habitability and resiliency of communities.

"I'm hoping that we take this science, this knowledge, and the engineering approaches, and somehow marry it and come up with a framework that can be used as a template for improving lives," Niyogi said.

by Jasmine Gulick

PHOTOS: LISA BOUCHER; DEV NIYOGI.



Geeta Persad
Assistant Professor

Growing up in Austin, Geeta Persad spent her childhood exploring the Texas Memorial Museum, auditing classes and attending evening lectures at The University of Texas at Austin. Now, 14 years after leaving the city to study at Stanford University as an undergraduate, Persad has returned to Austin as an assistant professor of climate science at the Jackson School of Geosciences.

"Coming home was a really big draw, being able to give back to the UT educational mission that played such a large role in my childhood," Persad said. "I have a long family and Austinite connection to the university."

After receiving a bachelor's degree in geophysics from Stanford University, Persad went on to earn a doctorate in atmospheric and oceanic sciences from Princeton University, where she was also a fellow in the Science, Technology, and Environmental Policy program. Persad said that working in policy helped her understand how policymakers and academic scientists look at data differently.

"It's been illuminating and helped me as a scientist realize the many different uses of our work," Persad said. "I enjoy having a foot in both worlds, producing the fundamental science and seeing how it's being used in the broader world."

As a climate modeler, Persad uses computer representations of the entire Earth system to understand the fundamentals of climate change. She's especially interested in aerosol particles, such as sulfur dioxide and black carbon.

Aerosol particles complicate climate change projections because the particles have a cooling effect that can mask warming.

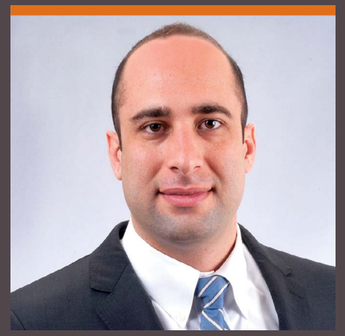
"Which is not to say that they're good things, because they have terrible effects on human health and precipitation," Persad said.

One of the questions Persad is most interested in is how aerosol emissions from different regions of the planet affect the climate system as a whole.

Persad said that she is looking forward to collaborating with other scientists in the Jackson School's Department of Geological Sciences and the University of Texas Institute for Geophysics to investigate aerosol effects and other climate modeling applications at the local, regional and global scales.

"It was really appealing to me to bring my expertise in atmospheric science into a department that has such a wide range of expertise and research activities going on," Persad said.

By Jasmine Gulick



Shayan Tavassoli
Research Associate

Drilling an oil well doesn't come cheap. In a time when oil prices are low, it's especially important that wells are optimally placed to get the most out of the reservoir. That's where Shayan Tavassoli comes in.

Tavassoli joined the Bureau of Economic Geology as a research associate in February 2020, right before oil prices took a major hit from the COVID-19 crisis. His work as a reservoir engineer in the Tight Oil Resource Assessment (TORA) group is improving production of tight oil resources—also known as unconventionals—which constitute more than 60% of U.S. crude oil production.

Before joining the bureau, Tavassoli was part of The University of Texas at Austin Department of Petroleum and Geosystems Engineering (PGE). He arrived in 2010 as a graduate student. After earning a doctorate, he continued on at PGE as a postdoctoral research fellow and research associate. He worked on several projects related to enhanced oil recovery, reservoir simulation and geological storage of carbon dioxide.

At TORA, Tavassoli is working to optimize well spacing by predicting reservoir behavior and well performance. In tight oil reservoirs, engineers frequently run into an issue called well interference—when one well's production causes a loss in production in another due to pressure depletion or fracture interference.

The work involves using data collected from wells and applying it to a basin-wide study using different machine learning algorithms. At the basin scale, Tavassoli and his group are able to determine how the reservoir's geology and other features influence production in tight oil resources.

His work is critically important now that oil prices are down and operators can't risk millions of dollars with each well drilled.

"There's no more room for trial and error," Tavassoli said.

Despite events such as the COVID-19 pandemic causing oil prices to drop, Tavassoli holds hope for the future of the oil and gas industry and energy security.

"Innovative research in this area is paramount if the United States wants to reduce oil imports and maximize its domestic oil production," he said.

By Emily Moskal

PHOTOS: GEETA PERSAD: SHAYAN TAVASSOLI: DANIEL TRUGMAN.

Daniel Trugman
Assistant Professor

The town of Los Alamos, New Mexico, is an unusual one. More than half of its residents work in the Los Alamos National Laboratory (LANL), a U.S. Department of Energy research center. Daniel Trugman's parents are among them.

Growing up, Trugman assumed he would be a physicist, just like his parents. He ended up taking a bit of a different path, becoming a geophysicist focusing on earthquake seismology. This fall, Trugman joined the Jackson School of Geosciences as an assistant professor.

"Our scientific assumptions about earthquakes are tested every day, and often times we're wrong, which is humbling," he said. "It's a constant process that helps us make better algorithms for earthquake early warning systems."

Trugman is an observational seismologist. His research seeks to answer questions such as: How do earthquakes get started? And why do earthquakes vary from one another?

Trugman earned a doctorate in geophysics at the University of California, San Diego. Upon receiving his degree, he returned home to Los Alamos for a postdoctoral position at the lab and stayed for 2½ years. But he felt like he was missing something.

"At a national lab, it's a different environment from a university," Trugman said. "There are a lot of great scientists, but there's not as much of a focus on mentoring or teaching."

By coincidence, Trugman interviewed with the Jackson School around the same time Claudia Mora, then the deputy leader of LANL's chemistry division, was interviewing for the position of dean. Trugman had never worked with Mora at the lab, but he was pleasantly surprised when he saw the announcement that she had been chosen for the position.

"There were jokes at LANL that Dean Mora had stolen me from the lab and brought me with her to UT, but, in reality, there was no relation," Trugman said. "We were getting hired at the same time from two very different committees."

Among the diverse array of research at the Jackson School, Trugman said he is already fitting right in.

"When I came here, I felt like I was already home," he said. "There is a lot I can learn from everyone working here, but also a lot I think I can contribute."

By Jasmine Gulick

FROM PAGE 79 | Ron Steel

Steel is quick to point out that his many graduate students helped create this legacy. In total, he has supervised over 200 geologists at the University of Bergen, the University of Wyoming and The University of Texas at Austin. He plans to return to the beautiful field site in Argentina with some of his current students to finalize his mapping of that continental margin.

FROM PAGE 80 | Ken Wisian

such to produce—to use a military term—'actionable information' for everything from the individual citizen up through a government decision maker."

Geothermal is another of Wisian's passions. He is the geosciences lead on the Department of Energy-sponsored Geothermal Entrepreneurship Organization, an innovation-focused project led by UT. The project seeks to build on current drilling technology in the oil and gas industry to make carbon-free geothermal energy available worldwide. This would be done by building closed-loop or semi-open loop systems to circulate a fluid and capture the heat of the planet's core to generate electricity. The goal is to enable economically viable drilling at temperatures of 660 degrees Fahrenheit (350 Celsius) and at depths of 30,000 feet (about 10 kilometers) within a decade.

The bureau really hits a sweet spot for this project, he said, and can play a key role in helping the oil and gas industry pivot to a new energy source that could be a perfect fit for its technology and workforce skills, as well as bringing together the earth science and engineering disciplines needed for the research and development to enable this paradigm shift.

"Our ability to put together multidisciplinary teams with all of our knowledge sets really gives us the ability to characterize the subsurface N-dimensionally for this new wave of geothermal," he said. "Obviously just knowing the temperature at depth is a big deal, but you need to know the stress regime, the permeability and pressure structure, and lithology, and then to monitor the projects through seismicity. That's something we can do as well as anybody in the world."

PHOTO: JACKSON SCHOOL.

Sharon Mosher Recognized as Marcus Milling Legendary Geoscientist

Professor Sharon Mosher, the former dean of the Jackson School of Geosciences and the William Stamps Farish Chair in Geology, has been awarded the 2020 Marcus Milling Legendary Geoscientist Medal by the American Geosciences Institute (AGI).

"I am very honored to receive this award, following so many distinguished past recipients," Mosher said. "Geosciences has been my lifelong passion, and I have been fortunate to have so many opportunities to contribute. But the best part has been working with so many wonderful fellow geoscientists."

The Marcus Milling Legendary Geoscientist Medal is a lifetime achievement award, given in recognition of an individual's high-quality basic and applied science achievements in the earth sciences. The award, established in 1999, was named in late 2006. Marcus Milling was an ardent and tireless champion of geoscience education, policy and information services who served as AGI's executive director from 1992 to July of 2006, when he transitioned to a senior adviser role.

"Sharon Mosher's long service to AGI, as an officer and as a former president, is well known," said AGI President Carolyn Olson. "What many of us in the geoscience professional community have come to admire most in Sharon is her thoughtful leadership, vision and fortitude in shaping the future of the geoscience community."

Mosher gained renown as a major contributor to the geological sciences through her research in tectonics, structural geology and petrology, her work improving geoscience education, and her leadership within the geoscience community. She is well known for her recent role as Jackson School dean, where she faced the challenges of leading three independent units of geoscience as one successful school. Under Mosher's leadership, the Jackson School earned its ranking as one of the top-rated geoscience schools in the United States.

Additionally, Mosher had the vision and accomplishment of leading the development of GeoScienceWorld, an international journal aggregation for geologists and a nonprofit startup that has grown to be a substantial force in worldwide scientific digital access for universities and companies. Mosher has exerted far-reaching influence through her leadership in developing geoscience curricula for the future by gathering colleagues from around the world.

Mosher has served in several society leadership roles, including president of AGI (2012-2013), president of the Geological Society of America (GSA) (2000-2001), and chair of the Council of Scientific Society Presidents (2004). Her awards include the Association of Women Geologists Outstanding Educator Award (1990), the GSA Distinguished Service Award (2003) and the Alumni Achievement Award from the University of Illinois at Urbana-Champaign College of Liberal Arts & Sciences (2016).

"Sharon Mosher is never just a member of anything," said Robbie Gries, former president of the Geological Society of America, in nominating Mosher for the award. "She puts heart and soul into leadership, direction, fiscal stability, creative innovations and attention to the needs of all — all the while educating students, the public, colleagues and politicians. To follow her path in any organization is to be the lucky beneficiary of her wise impact and trailblazing."

This text was adapted from a release that originally appeared on the AGI website.

PHOTO: DANIEL STOCKLI. MAGAZINE: INSIGHT INTO DIVERSITY MAGAZINE.

Stockli Named New Department Chair

Professor Daniel Stockli has been selected as the new chair of the Department of Geological Sciences at the Jackson School of Geosciences. He will begin the position Jan. 16, 2021.

Stockli, who holds the Chevron Centennial Professorship in Geology, will replace Charles Kerans, who has held the position since 2016 and is now at the close of his four-year term. Stockli said that he is looking forward to advancing research and education at the Jackson School while working to build a more diverse and inclusive geosciences community.

"Without any doubt, being selected as the next DGS chair is a tremendous honor, and I am very excited to work with Dean Mora and the other unit leaders, faculty and students for the next four years," said Stockli. "While we are facing a global pandemic, overdue societal and cultural changes, and a plethora of global and environmental challenges, these also present us with tremendous opportunities for DGS and JSG to lead and to spearhead change. These are opportunities that we need to embrace as the No. 1 geology program."

Stockli joined the Jackson School in 2011 as a professor. Since then, he has built a thriving thermochronology and geochronology laboratory that investigates the thermal and temporal aspects of tectonic, petrologic, stratigraphic and geomorphologic processes. He is a mentor to researchers at all levels of their educational careers, with a research team that spans from undergraduate students to postdoctoral researchers. From 2012 to 2018, he also served as the chair of the school's Solid Earth & Tectonic Processes research theme.

In addition, Stockli is a fellow of the Geological Society of America and a recipient of the Jackson School's Outstanding Researcher Award.

"Danny will be an ambitious and visionary leader, with energy to inspire cooperation and drive innovation to improve the quality of education of our students," said Dean Claudia Mora. "He is dedicated to a department that is collegial, transparent, diverse and inclusive, and eager to support the creation of a department that is far greater than the sum of its parts."

Jackson School Wins Award from National Diversity and Inclusion Magazine

The Jackson School of Geosciences has been honored for its diversity and outreach efforts with a 2020 Inspiring Programs in STEM Award from *INSIGHT Into Diversity* magazine, the largest and oldest diversity and inclusion publication in higher education.

The magazine recognized a collection of programs working to broaden participation in the geosciences run by the Jackson School's Office of Broader Impacts of Geoscience Research. The programs include GeoFORCE Texas, a nationally recognized outreach program that introduces students from underserved areas of the state to geoscience by taking them on field trips to geologically significant sites across the country each summer throughout high school.

Other Jackson School programs and efforts that contributed to the award include:

- A long-running partnership with Fort Valley State University, a historically Black university in Georgia;
- Professional development efforts for Texas middle and high school science teachers with significant numbers of Black and Latino students;
- Enhancing Diversity in Geoscience Education, a program that brings together prospective graduate students and Jackson School graduate faculty members for a day to raise the profile of the students from underrepresented groups in the graduate school applicant pool;
- A math and science institute, which helps prepare alumni of GeoFORCE for the rigors of math and chemistry in college; and
- Undergraduate research training for alumni of GeoFORCE, students from institutions with significant Black and Latino enrollees, and students at other colleges.

Lack of diversity among students, researchers and faculty members is an issue in all STEM fields, particularly

the geosciences. The Jackson School has focused on tackling the problem at many levels, including reaching diverse students at a young age and supporting them through secondary and higher education. The school is currently reviewing its programs and plans to increase diversity and inclusion training among faculty and staff members.

"This is a multifaceted challenge, and the truth is we have a long way to go," said Dean Claudia Mora. "We have been working hard to bring students from all walks of life to the geosciences and to make our school an open and inclusive environment. I am very proud of this recognition and all the people who work so hard every day to make our diversity and inclusion efforts successful. And I am excited about improvements and changes we are making to our programs to make the school an even better place."

The Inspiring Programs in STEM Award honors colleges and universities that encourage and assist students from underrepresented groups to enter STEM fields. GeoFORCE Texas and other recipients were featured in the September 2020 issue of *INSIGHT Into Diversity* magazine.

"We know that many STEM programs are not always recognized for their success, dedication and mentorship for underrepresented students," said Lenore Pearlstein, owner and publisher of *INSIGHT Into Diversity* magazine. "We want to honor the schools and organizations that have created programs that inspire and encourage young people who may currently be in or are interested in a future career in STEM. We are proud to honor these programs as role models to other institutions of higher education and beyond."

PHOTO: KERRY COOK.

Cook Honored by American Meteorological Society

Kerry Cook, a professor in the Jackson School of Geosciences Department of Geological Sciences, has been awarded the inaugural Simpson Tropical Meteorology Research Award from the American Meteorological Society.

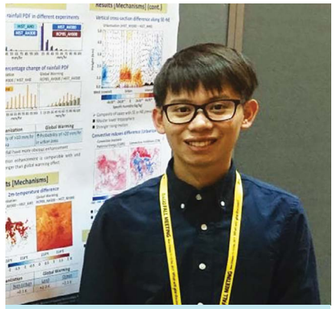
The society honored Cook with the award "for expanding our knowledge of the physics and dynamics of tropical monsoon regimes, especially the West African Monsoon and related phenomena, using observations and models."

The award is named for Joanne Simpson (1923-2010), who was the first woman in the U.S. to receive a Ph.D. in meteorology. Simpson made fundamental advances in the understanding of tropical convection, cyclones and rainfall, and she was also known for being a mentor who encouraged other women in the field.

"This recognition from my peers in the atmospheric science community is especially meaningful because of its association with Joanne Simpson," Cook said. "Not only did she make fundamental contributions to our quantitative understanding of tropical convection and its representation in numerical models, but she was a major force at NASA in the development of satellite observing systems of tropical rainfall. She is also known for her unflagging support for diversity in the earth sciences."

Cook has been at The University of Texas at Austin since 2008. She began her career at the National Oceanic and Atmospheric Administration's Geophysical Fluid Dynamics Lab at Princeton University, followed by 18 years as a professor at Cornell University. At UT, she teaches an undergraduate course in global warming and graduate courses in atmospheric dynamics. A second edition of her textbook, "Climate Dynamics," will be published by Princeton University Press in 2021. Cook is a fellow of the American Meteorological Society and has served on the board of trustees of the University Corporation for Atmospheric Research and as an editor of the *Journal of Climate*. She is currently the chair of the American Meteorological Society's Board of Climate Variability and Change and serves on the National Science Foundation's GEO Advisory Council.

Cook's research centers on predicting and understanding climate change and climate variability around the world, with an emphasis on the tropics, where a large portion of the world's most vulnerable population resides. She and her group use state-of-the-art numerical models of the climate system, including high-resolution models that resolve tropical convection, along with observational analysis to advance scientific understanding about how atmospheric circulation and precipitation fields are related. A recent focus of research is on mesoscale convective systems and their controls on intense rainfall events.



NASA INVESTIGATOR: SAMUEL FUNG. FULBRIGHT: EDWARD CLENNETT. AAPG STUDENT GROUP: AAPG.

Fung Named a NASA Future Investigator

Jackson School of Geosciences doctoral student Samuel Fung has been named a Future Investigator in NASA Earth and Space Science and Technology (FINESST). NASA awarded Fung a $134,976 grant for his research on the effect of urban resilience enhancing strategies on modulating extreme rainfall in Houston.

Fung is one of 62 to receive the award out of 341 applicants. The award supports graduate student-designed research projects that contribute to NASA's science, technology and exploration goals. Fung's research looks at the link between the urban heat island (UHI) effect and extreme rain events in Houston, as well as efforts to mitigate the UHI through green roofs, vegetation and other methods. He's specifically studying the effect of the mitigation strategies on the distribution of rainfall throughout Houston during extreme events. The outcomes should inform urban planners about the unintended consequences of these strategies with respect to precipitation enhancement and flood risk.

"I am deeply honored to receive the FINESST award. It recognizes the work and ideas that I have been developing since I entered UT," Fung said. "I want to take this opportunity to thank professors Zong-Liang Yang, Dev Niyogi (both of the Jackson School) and Chi-Yung Tam (Chinese University of Hong Kong) for their guidance and support."

In choosing Fung's proposal, a NASA panel commented that his approach to the issue was "potentially novel in several aspects," contained a "well-defined hypothesis," and is novel in that it investigates the effects of UHI on precipitation.

"Given that climate change may amplify UHI effects as well as extreme weather events such as heavy rainfall, the proposal has outstanding merit," the panel concluded.

Clennett Receives Fulbright

Incoming doctoral student Edward Clennett received a Fulbright All Disciplines Postgraduate Award from the US-UK Fulbright Commission. The award provides funding for Clennett's first year as a graduate student at the Jackson School of Geosciences.

Clennett earned a master's degree in earth sciences from the University of Oxford, where he conducted research on plate tectonics. He will be continuing his tectonics research at the Jackson School, working closely with professors Thorsten Becker and Claudio Faccenna.

"I really love fundamental research into geodynamics and tectonics, and all the processes that shape our planet," Clennett said. "I'm also keen on relating my research in tectonics to things like climate science and natural hazards and all those important issues that are so well known around the world, but that people wouldn't necessarily recognize as 'Oh, geosciences!'"

AAPG Student Group Honored as Outstanding Chapter

The Texas Longhorn Student Chapter of the American Association of Petroleum Geologists (AAPG), a group based out of the Jackson School of Geosciences, has received the 2020 Outstanding Student Chapter Award for the Gulf Coast Section.

The award honors enthusiastic student chapters that "capitalize on opportunities to enrich the experiences of its membership" and includes a $2,000 prize. Recipients are selected by the AAPG Student Chapter Committee and the AAPG Programs team, which considers award-winning chapters as those that "best communicate the breadth of its activities and the impact it has on formulating the education and professional demeanor of its membership."

The chapter was recognized for the award during a virtual ceremony hosted by the AAPG in July.

"I was happy when I heard that the Longhorn AAPG student chapter received this award," said chapter President Kiara Gomez. "This is a

reflection of the hard work that the previous leadership team, led by Cole Speed, has done in providing AAPG members with amazing events, workshops and lectures. The monetary award will allow us to bring in diverse industry speakers for the upcoming years, so stay tuned for more updates!"

Awards

Common Abbreviations:

AAPG..... American Association of Petroleum Geologists
AGS..... Austin Geological Society
AGU ..... American Geophysical Union
BEG..... Bureau of Economic Geology
DGS ..... Dept. of Geological Sciences
EERI .....Earthquake Engineering Research Institute
GSA.....Geological Society of America
GSEC .....Graduate Student Executive Committee
IAS ..... International Association of Sedimentologists
JSG ..... Jackson School of Geosciences
SEG... Society of Exploration Geophysicists
SEPM... Society for Sedimentary Geology
SSA.....Seismological Society of America
UTIG ..... Institute for Geophysics

FACULTY AND RESEARCHERS

SAHAR BAKHSHIAN
Runner-up, Tinker Family Publication Award, BEG

OWEN CALLAHAN
Career Development Publication Award, BEG

GINNY CATANIA
Research Excellence Award, UTIG

GAIL CHRISTESON
Knebel Teaching Award, DGS
Joseph C. Walter Excellence Award, JSG
Director's Circle of Excellence, UTIG

JULIA CLARKE
Outstanding Educator Award, JSG

KERRY COOK
Simpson Tropical Meteorology Research Award, American Meteorological Society

JACOB A. COVAULT
Runner-up, Tinker Family Publication Award, BEG

IAN DALZIEL
Director's Circle of Excellence, UTIG

YI FANG
Rocha Medal Runner Up, International Society for Rock Mechanics and Rock Engineering

OMAR GHATTAS
Geosciences Career Prize, Society for Industrial and Applied Mathematics
Computational Science & Engineering Best Paper, Society for Industrial and Applied Mathematics

RAMÓN GIL-EGUI
Tinker Family Publication Award, BEG

SHUOSHUO HAN
Young Researcher Award

PETER HENNINGS
DEG Best Paper Award , AAPG

BRIAN HORTON
Geosciences Distinguished Alumni Award, University of Arizona
Outstanding Researcher Award, UTIG

SEYYED A. HOSSEINI
Tinker Family Publication Award, BEG
Runner-up, Tinker Family Publication Award, BEG

RICHARD KYLE
Legion of Honor, Society for Mining, Metallurgy, and Exploration

LUC LAVIER
Director's Circle of Excellence, UTIG

CHRISTOPHER LOWERY
Director's Circle of Excellence, UTIG

VANESSA NUÑEZ-LÓPEZ
Tinker Family Publication Award, BEG

ROWAN MARTINDALE
Best Paper, Papers in Palaeontology
CAREER Award, NSF

ASHLEY MATHENY
Knebel Teaching Award, DGS

SHARON MOSHER
Marcus Milling Legendary Geoscientist Medal

DEV NIYOGI
Visiting/Adjunct Professor, Centre of Excellence in Disaster Mitigation & Management at Indian Institute of Technology

YUKO OKUMURA
Director's Circle of Excellence, UTIG

PHIL ORLANDINI
Microbeam Lab Energy Efficiency Pilot, University of Texas Green Fund

CORNELIA RASMUSSEN
Outstanding Postdoc, UTIG

ALEXANDROS SAVVAIDIS
Top 10% Most Downloaded Paper, Journal of Geophysical Research: Solid Earth

BRIDGET R. SCANLON
Runner-up, Tinker Family Publication Award, BEG

MRINAL SEN
Top 25 Presentation, SEG
Top 25 Presentation (for a separate presentation), SEG

TIM SHANAHAN
Knebel Teaching Award, DGS

ZOLTÁN SYLVESTER
Runner-up, Tinker Family Publication Award, BEG

FRED TAYLOR
Career Award, UTIG

DANIEL TRUGMAN
Geophysical Research Letters Editor's Highlight, AGU
Editors' Citation for Excellence in Refereeing: Geophysical Research Letters, AGU
Top 50 Science Story, Discover Magazine
HPC Innovation Excellence Award, Hyperion Research
Top Downloaded Paper Award, Geophysical Research Letters, AGU

JINYU ZHANG
Editor's Choice, Basin Research
Robert Mitchum Award, European Association of Geoscientists and Engineers

TEXNET-CISR TEAM (PETER HENNINGS, ELLEN RATHJE AND ALEXANDROS SAVVAIDIS)
Outstanding Research Award, JSG

QIAN YANG
Runner-up, Tinker Family Publication Award, BEG

PROMOTIONS

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Senior Research Scientist

PATRICK HEIMBACH
Professor

JESSICA KOLSTAD-KIM
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Professor

ROWAN MARTINDALE
Associate Professor

JUDSON PARTIN
Research Scientist

ESTIBALITZ UKAR
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TONGWEI ZHAG
Senior Research Scientist

STUDENTS

ANA MARIA RESTREPO ACEVEDO
External Research Grant Matching Funds, The University of Texas at Austin

WADE AUBIN
Fall 2019 Outstanding TA, DGS

EMILY BAMBER
Graduate Fellowship, JSG

GRACE BEAUDOIN
Spring 2020 Outstanding TA, DGS

KRISTINA BUTLER
Graduate Student Research, GSA

KRISTIAN CHAN
NASA/Texas Space Grant Consortium Fellowship, Texas Space Grant Consortium

EDWARD CLENNETT
Fulbright All Disciplines Postgraduate Award, US-UK Fulbright Commission
UK Onshore Geophysical Library Prize, UK Onshore Geophysical Library
Second Prize, Halliburton Landmark Earth Model Award, Halliburton Landmark

ETHAN M. CONRAD
Estwing Award, University of Florida

SARAH N. DAVIS
Whitney Endowed Presidential Scholarship, JSG

ARNAB DHARA
Scholarship, Dallas Geophysical Society
SEG/James and Ruth Harrison Scholarship, SEG
SEG Foundation Scholarship, SEG

ANTHONY EDGINGTON
Best Poster, GSA-SGD/SEPM Student Research Poster Competition
L. Austin Weeks Undergraduate Grant, AAPG Foundation
Undergraduate Research Fellowship, UT Office of Undergraduate Research

ABDULAH ELJALAFI
First Place Poster, HGS/EAGE Conference on Latin America
Grant, GSA

THOMAS ETZEL
Graduate Student Best Paper Runner Up, DGS
Spring 2020 Technical Sessions Best Speaker, DGS

MEGAN E. FLANSBURG
W.R. Meuhlberger Fellow in Structural Geology and Tectonics, JSG

CAITLIN FOUX
Estwing Hammer Award, DGS

SAMUEL FUNG
Spring 2020 Outstanding TA, DGS
Future Investigator in NASA Earth and Space Science and Technology, NASA

YUQIAN (PHILOMENA) GAN
Fall 2019 Outstanding TA, DGS

KIARA GOMEZ
William Siok Graduate Scholarship Winner, American Institute of Petroleum Geologists (AIPG)
2020 Travel & Research Fellowship, Woodrow Wilson National Fellowship Foundation

HIMA J. HASSENRUCK-GUDIPATI
P.E.O. Scholar Award, Philanthropic Educational Organization

MARCO GUIROLA
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JAIME HIRTZ
Grants-In-Aid, AAPG

ESTEFANIA SALGADO JAUREGUI
Best Student Paper, GSA Division of Geology and Society

CHELSEA MACKAMAN-LOFLAND
Postdoctoral Research Fellowship, NSF

JOSHUA MALONE
Senior Research Award, Augustana College
Joseph M. Hoare Prestigious Merit Scholarship in Geology, Augustana College

JASMINE MASON
Graduate Student Best Paper Runner Up, DGS

NICK MESZAROS
Graduate student research grant, GSA

ROSALIND MOREMAN
Houston Geological Society Undergraduate Foundation Scholarship, Houston Geological Society

MARGARET MURAKAMI
Best Undergraduate Poster, UT Energy Week
Best Poster, BEG

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Graduate Research Fellowship Program, National Science Foundation

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Graduate Student Research Grant, GSA
Off-Campus Research Award, JSG

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GSA CARES Grant, GSA

SAM ROBBINS
Master's Saturday Best Speaker, DGS

COLIN SCHROEDER
Fall 2019 Technical Sessions Best Speaker, DGS

BRANDON SHUCK
Outstanding Graduate Student Award, UTIG
Graduate Student Best Paper Runner Up, DGS

SINJINI SINHA
Mid-American Paleontology Society (MAPS) Outstanding Student Research Award, Paleontological Society
Graduate Student Research Grant, GSA
International Geological Congress 2020 Travel Grant, GSA and U.S. National Committee for the International Union of Geological Sciences
Southeastern Section Travel Grant, GSA

BEN SMITH
Graduate Student Best Paper, DGS

GAIA STUCKY DE QUAY
Postdoctoral Fellowship, JSG

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Robert G. Bone Scholarship, Illinois State University

QIQI WANG
Off-campus Research Award, JSG
Summer Research Analytical Fund, JSG

WEN-YING WU
Data Visualization and Storytelling Competition Grand Prize, AGU/NASA

XIAN WU
Outstanding Student Presentation Award, AGU
Advanced Study Program Postdoctoral Fellowship, NCAR

Graduate Student Best Paper Runner Up, DGS

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Student Assistance Grant, SEPM

ZHIKAI (BEN) ZHONG
Scholarship, Texas Energy Council

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Eleanor Picard Excellence Award, UTIG

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Outstanding Service Award, JSG

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Guion Library Staff Honors, DGS

BEN HESTER
Outstanding Staff, UTIG

COLLEEN LYON
Guion Library Staff Honors, DGS

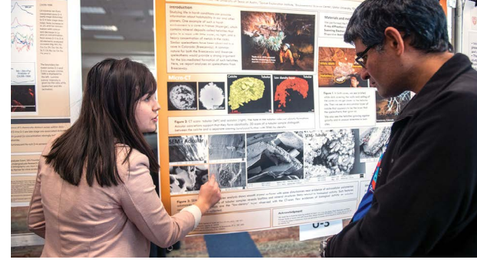
DENA MILLER
Staff Excellence Award, BEG

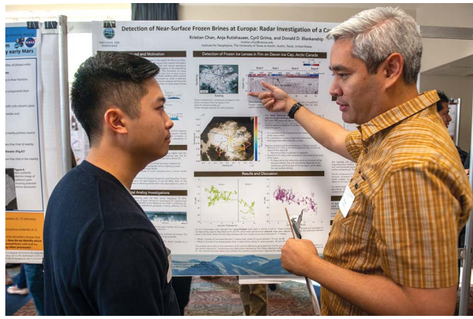
ANNE MORGAN
Guion Library Staff Honors, DGS

EMILY MOSKAL
Tinker Family Publication Award, BEG

ADAM PAPENDIECK
Frederick Eby Research Prize in Humanistic Studies, UT

JSG COMMUNICATIONS TEAM (ANTON CAPUTO, MONICA KORTSHA AND LAURA MARTIN)
Staff Excellence Award, JSG





STUDENT RESEARCH SYMPOSIUM AWARDS

In February 2020, the Jackson School's Graduate Student Executive Committee hosted its 9th Annual Research Symposium. Winners and honorable mentions are as follows:

LATE-CAREER PH.D. STUDENT

1st Place: Chelsea Mackaman-Lofland: Kinematic development and structural architecture of the southern Central Andean fold-thrust belt (31-33°S): implications for Andean deformation modes and driving mechanisms

2nd Place: Brandon Shuck: Strike-Slip Enables Subduction Initiation Beneath a Failed Rift: New Seismic Constraints from Puysegur Margin, New Zealand

Honorable Mention: Sophie Goliber: Characterizing buoyant conditions of marine-terminating glaciers in West Greenland

LATE-CAREER MASTER'S STUDENT

1st Place: Esben Pedersen: Recovery After Ocean Anoxic Events: A Closer Look at the Carbonate Factory Response Preserved in The Pearsall Formation in Central Texas Following OAE 1

2nd Place: Micaela Pedrazas Hinojos: Ice-free beaches and lagoon sediment in the Arctic coast

Honorable Mention: Samuel Robbins: Constraining the tectono-thermal evolution of the Egyptian Red Sea margin: linking observations from the proximal to the hyperextended rift domain

EARLY-CAREER GRADUATE STUDENT

1st Place: Michelle Tebolt: The Geometry of Fan Features on Mars

2nd Place: Cole Speed: Linking Geomorphology and Stratigraphy at an Ancient Fluvial Avulsion Node: An example from the Cretaceous Cedar Mountain Formation, Eastern Utah, USA

Honorable Mention: Ethan Conrad: Plexiglass melt during rotary-shear experiments as an analog of pseudotachylite formation

UNDERGRADUATE STUDENT

1st Place: Carole Lakrout: Biotic Influence on Speleothem Morphology

2nd Place: Ryan Herring: Deducing the Timing and Magnitude of Late Quaternary Mississippi River Deltaic Progradation and Retrogradation Coeval with the Waning Phase of the Last Glacio-eustatic Cycle by Modeling Volumetric Flooding Rate and Sediment Discharge Since the Cessation of the Late Wisconsin Glacial Stage

Honorable Mention: Anthony Edgington: Stratigraphic Architecture and Provenance of the Cretaceous Cerro Barcino Formation, Patagonian Broken Foreland Basin, Southern Argentina

BEST REPRESENTED RESEARCH GROUP

1st Place: David Mohrig Research Group

2nd Place: Daniella Rempe Research Group

PHOTOS: JACKSON SCHOOL.

CLOCKWISE: UNDERGRADUATE CAROLE LAKROUT SHARES HER RESEARCH ON SPELEOTHEMS; GRADUATE STUDENT KRISTIAN CHAN (LEFT) TALKS WITH PROFESSOR BAYANI CARDENAS; GRADUATE STUDENT ERIC GOLDFARB (LEFT) AMONG RESEARCH SYMPOSIUM PARTICIPANTS.

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WE ARE GRATEFUL TO OUR DONORS, WHETHER IT IS THEIR FIRST OR 100TH TIME GIVING TO THE JACKSON SCHOOL OF GEOSCIENCES. WE WOULD LIKE TO RECOGNIZE ALL DONORS WHO HAVE DESIGNATED THE JACKSON SCHOOL IN THEIR ESTATE PLANS, DONORS WHO ARE MEMBERS OF OUR GIVING SOCIETIES, AND ANNUAL DONORS FOR THEIR LONG-STANDING FAITHFUL CONTRIBUTIONS. THANK YOU FOR YOUR CONTINUED SUPPORT TO ASSURE THE JACKSON SCHOOL PROVIDES A SUPERIOR EDUCATION TO BUDDING GEOSCIENTISTS AND CONTINUES TO LEAD THE WAY IN TRANSFORMATIVE RESEARCH.

Texas Leadership Society

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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Flawn Circle of Excellence

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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Dianne & Les White
Cathy & Chuck Williamson

Katie Society

The Katie Society recognizes individuals who have given cumulative gifts of $500,000 or more. It was established in 2014 in fond remembrance of Katherine G. "Katie" Jackson, beloved wife of the late John A. Jackson. Katie was a great philanthropist and Jack's partner in all things, including the creation and naming of the Jackson School of Geosciences.

David Arctur
Kathleen Howard
Kenneth Neavel

L.T. Barrow Founders Circle

The L.T. Barrow Founders Circle recognizes friends and alumni who have given cumulative gifts of $100,000 and above. Named after Leonidas T. and Laura T. Barrow, creators of the first Geology Foundation endowment in 1953, Barrow Founders Circle members honor the legacy of these two guiding spirits of geoscience education at The University of Texas at Austin.

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Hill Society

The Hill Society honors friends and alumni who have given $10,000 or more over their lifetime in support of the Jackson School. This society is named after Robert T. Hill, the first professor and chair of the Department of Geology and a founding member of the UT Mineral Survey, which would later become the Bureau of Economic Geology.

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We honor the following individuals who have generously contributed to the Jackson School of Geosciences during the 2018–2019 fiscal year. Annual contributions are critical to the Jackson School. As a result of annual contributions, students participated in field experiences, faculty taught and conducted research, students received scholarships and scientific equipment was purchased.

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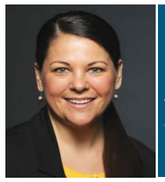

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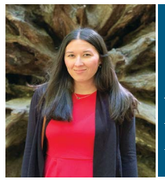

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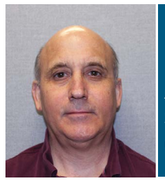

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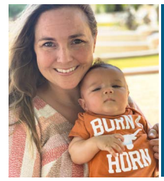

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ALUMNI NOTES

1950's

Walter V. Boyle (B.S. '54, M.A. '55) shares, "Because of the coronavirus pandemic outbreak, Vada's and my life has drastically changed since February 2020. We have become more or less "Stay at Homes"—little socializing and partying with our friends, no Houston Geological Society meetings, no church, no Houston Symphony Concerts and Alley Theater performances—only phone conversations and e-mail notes to my friends—Vada and I have learned to attend "Zoom" meetings with our friends which is great. We also had to cancel a Crystal Cruise to Montreal, Quebec, Boston and New York. I really missed getting to attend the JSG spring meeting in Austin and getting to see old classmates and the Jackson School of Geosciences staff. In conclusion, it has been a distinct honor and privilege to have known former Dean Sharon Mosher for the past ten years, and to see her help build the Jackson School of Geosciences into the largest geoscience program in the country and ranked No. 1 in geology by the *U.S. News & World Report* 2019 edition of "Best Graduate Schools". Continued success to former Dean Mosher when she returns to her research and wrapping up two major national geosciences education initiatives for the National Science Foundation."

Jimmie Russell (B.A. '52, M.A. '54) writes, "YING/YANG's—FAITH & LOVE: words I often think. My friend Master Sergeant Jesse Wayne Green's service was held January 17, 2020 at Greater Mount Zion Baptist Church in East Austin. I contributed some eulogistic remembrances. I was an Honorary Pallbearer. We will be reunited at Fort Hood, at the Military Cemetery. We were GI "Buddies" in 1956. TAPS, JESSE, REST-IN-PEACE. Doctor Folk told me "We do things differently, than when you were here". The "Boss" is correct, "THE TIMES THEY ARE A-CHANGING". I spent many hours in labs pursuing my degrees, but there was never a lab of this type! The VIRUS has caused me to have many interruptions of activities. However, as disabilities have prevented me from getting out and about for at least a year, a colleague said I appear to have been "under house arrest" for quite sometime. It was contracted by the compound's groundskeeper and his wife, but fortunately both had mild cases. Sadly, complications by the virus resulted in the death of a geological colleague of many years, Dr. E. Gerald Wermund, "Jerry". Also, my mineralogy lab-partner, attributable to hard-work and an "A" passed away: Adios Floyd Sabins. Communication with friends during this time has given me much pleasure. I can be reached at jimmierussell@gmail.com. I will enjoy hearing from you. Also, I answer the phone, but I walk slow, so HANG ON! & HOOK 'EM."

Daniel L. Smith (B.S. '58) says, "I continue being very active and busy with several things. My five grown kids, seven grandkids, and two great grandkids keep me young and always on my toes. I really enjoy my activity as a member of the Foundation Advisory Council and other UT activities. I continue to be active in AAPG, SIPES, GSA and Houston Geological Society. I manage to work most days generating new prospects. I'm not bored."

Theodore Edward Stanzel (B.S. '56) writes, "Going about our changed lifestyle brought about by the pandemic: We stay closer to home eliminating air travel and cruise lines in the interest of health and safety. Our travel agenda has changed to visiting interesting sights in Texas nearby counties of Fayette, Colorado, Lavaca, Lee and Washington. Many small towns and roadside points of interest. Wanda and I also are planning more extensive trips across the northern and western United States to observe the many historic and geologic points of interest. Happy travels."

Leslie Pittman White (B.S. '56) shares, "Dianne and I continue plugging on along here in southwest Austin. We have been mostly sheltering in place at home. It is no big deal. We have been together 58 years, so we think we know pretty well how to do this. When people our age are told that it is proper to lay around the house all day, the instruction is not entirely unwelcome. Another advantage that the aged have is the speedy passage of time. I remember, in the sixth or seventh grade, school would let out in May, and you did not have to go back for the rest of your life. Summer would last forever. At age 88 it does not work like that. June went by in less than a couple of weeks and July, even less than that. It is kinda fun getting to be this old. It is a little like standing on a high place on a clear day and being able to see a lot of things. And the past does not seem to be far away. I remember, as if it happened this morning, that September day in 1951 when I hitch-hiked from Waco to Austin and enrolled in this university. I walked through the Main Building down that long hallway on the ground level. I came out the east end and saw the geology building for the first time. I admired the frieze around the building with the models of fossils and crystals. I looked a long time at the inscription over the south door: "O Earth What Changes Hast Thou Seen." Today I think, "Boy, it sure has, hasn't it." And now we have that somewhat parallel thought, "What Starts Here Changes The World." I can tell you for sure, what started here changed MY world. I was a self-supporting student. The four year degree took five years. At the end of those years I had a degree, I had an education, I had a job, I had a profession and I had a hobby, an avocation that would entertain and intrigue me for the rest of my days. I had a love of learning and an insatiable curiosity. I had friendships that would outlast lives. And I had an inseparable connection with this sterling institution that would become the Jackson School of Geosciences. I am so proud of this school. I am so very proud to be a part of it."

1960's

Joe Norman Meadows (B.A. '62) says, "Hope you and your families are well. We have been skipped by the virus and are thankful for that." Joe can be contacted at joemeadows@sbcglobal.net.

Tom Patty (M.A. '68) writes, "With the virus this year there have been efforts to continue work at the WJE Petrographic Lab, mentoring to the new geologist and petrographers about Central Texas geology and aggregate sources. Some weekend geologic consulting projects have continued mostly in floodplain areas along the Brazos and Colorado Rivers. Recent drilling in eastern Williamson County has had no results but efforts are continuing. There is still a shortage of aggregates for the readymix concrete industry with the continued growth in the central Texas area. So I will keep looking. Just before the virus shut things down I presented a paper PERMIAN AGE BEAVERBURK LIMESTONE: LOCATION, CHEMISTRY, AND ARCHITECTURAL USES at 54th Annual Meeting GSA South-Central Section March 9-10 in Fort Worth, Texas. Since the passing of wife JoAnn in late 2017, I have had chances to travel with the kids and grandkids in addition to keeping the house and yard in shape. Hopefully when the virus plays out we can get back to visiting our friends on campus and at the Pickle Research Center. These have been trying times. I can still be reached at tspgeorock@gmail.com."

Rubin Amos Schultz, Jr. (B.S. '61) says, "Still enjoying retirement, traveling and grandkids. This photo is from last November in Branson, Missouri visiting with Daniel O'Donnell."

William C. Young, III (B.A. '61) shares, "Still enjoying retirement, although I'm hunkered down at present, and missing my travels and cruises. All is well, and I'm looking forward to the end of the virus and its problems."

1970's

Elmo Brown (B.A. '76) says, "Like everyone else in the world, Kathy and I have been homebound for the last several months. However, before the virus made its unannounced entrance, we did have the opportunity to reconnect with some college buddies. Now that we live in Kerrville, and I am a member of the STGS, we were also able to meet up with Bonnie Weise, John Long and Ted Flanigan. This year, both John and Ted were selected to receive the 2020 STGS Honorary Member Award; very well deserved. We were able to visit Clay Hunter and his wife Nancy in Golden, CO. They too are laying low, with Clay focusing on improving his already excellent banjo and guitar playing. And speaking of guitar playing, Paul Garrison came down from Wyoming to play in a gig or two with Ted Flanigan, who plays bass guitar in venues around the area (at least that was the case before the March shutdown). Some believe that going to college is to fill our heads with important knowledge, which is true, but it is also to fill our hearts with the friendships we make along the way."

Roger Q. Callaway (B.S. '70) says, "Let's see, my accomplishments and activities since last year, or was it the year before.. Only two years have slipped by it seems. The major accomplishment was in 2019, when I got stopped in time on the freeway, and the F-150 behind me did not. Briefly, I was rattling around in my little Nissan truck, sort of like the pea in Coach's whistle. The accomplishment was, the truck died, but I didn't! Not even badly hurt. It took most of a year after, but I bought another pickup. Balance was restored to the Force. I had great plans of travel, but, probably 2 weeks after I bought the truck, NC went into COVID Lockdown. Well, plans have a long shelf life. There's always 2021, or 2022. Until then, I'm making some effort to keep my marbles in the coffee can. Here at the deadline to submit my notes, I left the porch, and the hummingbirds and their acrobatics, and forced myself into the the house and to the keyboard. With greater distance to the Good Old Days, I see my lapses, missteps, and escapes from opportunities less as tragedy and more as experience. Certainly the second go at UT from '75 through '77, and the attendant B.S. in Geology was the buoy that kept me afloat. Here's my hat off to old pals and surviving teachers." Roger can be contacted at rqcallaway@gmail.com.

Frank G. Cornish (M.A. '75) writes, "I'm still exploring Texas Gulf Coast: part time consultant for Hurd Enterprises of San Antonio. Our Geological Society is trying to figure out how we survive this covid and oil price crisis just like everyone else. I'm still building a photo art career, but that, too is affected by closures of galleries and Art Centers. We're all sheltering in place waiting for covid vaccines and trying not to catch it yet. I have three grandchildren including two one-year-old boys each from

different sons. So with our granddaughter of four, we have some visiting we want to do, but cant."

Patricia Wood Dickerson (B.A. '70, Ph.D. '95) shares, "Far fewer wanderings to report this time, so they were savored all the more. June field work in Big Bend brought us exciting new results in a setting of profound silence, flaming sunrises and splendid star shows. Sparsely peopled, the Chihuahuan Desert is ideal for field research just now. Reported our discoveries at national and regional GSA meetings (no vegetal projectiles thrown!)—the most recent of which was just before lockdown. Since the Ides of March, other lecture gigs/tours/conferences—including a most eagerly anticipated field seminar in Spain and Portugal—have been cancelled. However, stimulating collaborations with Argentine compadres on kindred lower Paleozoic rocks there and in Big Bend continue (despite my abuse of the language). Teleworking on the GeoRef project is productive but short on discoveries of literary gems in the geology library, and on scintillating daily repartee. As for publications, a new textbook with our chapter on geological mapping methods (Dickerson & Muehlberger) is now out, and one of my photographs from Chilean Patagonia is part of a photo essay in the Journal of Latin American Geography. The Sul Ross U. graduate student, on whose committee I've been serving, defended his thesis with flying colors and has graduated. And most surprisingly, I've been approached by a seasoned spaceman about collaborating on field science strategies for the return to the Moon. An intense and interesting year!"

Ralph S. Kerr (M.A. '76) shares, "As with most people, I started 2020 with lots of plans, most of which were seriously disrupted by both the virus and then the downturn in the energy business. The year has been an exercise in dealing with change, which ironically is one of the topics that I have been coaching leaders on for the past decade. Meetings and courses have become fully virtual and I have become much better at using all the technology we have to continue to connect and work online. I have sought out and opened conversations with a lot of people that I have not heard from in a long time, rediscovered the pleasures of spending time working in the yard, and of being a learner again by taking online guitar lessons—all of which have been an unexpected blessing. Also, enjoyed the "Fossil Road Trip" series on PBS. I hope these types of programs instill the same love of geology in a new generation that I experienced when I was in middle school. Finally, I am grateful for the great education I got at UT, which got me started on a fulfilling career in the energy business." Ralph is an executive coach based in Houston, Texas.

David Kirchner (B.S. '74) is continuing with his professional career in the Great State of Arizona by managing his privately-owned consulting firm, which is known as Basin & Range Hydrogeologists, Inc. He has served as a member of the Advisory Council of UT's Geology Foundation since 2009 and resides in the City of Phoenix with his retired-geologist wife, Kathy. Their two sons, Kory and Kody, are thriving in the States of New Mexico and Arizona, respectively. Kody, the youngest of the Kirchner offsprings, is a mechanical engineer employed by Freeport-McMoRan's corporate office located in downtown Phoenix. His current working assignment is the Grasberg gold and copper mine in Papua, Indonesia. Kody earned his mechanical engineering degree at Northern Arizona University (NAU) in Flagstaff. Kory, the inveterate "dyed-in-the-merino-wool-gore-tex-fleece" outdoorsman and mountain-climbing adventurer, now lives in Albuquerque and is attending the University of New Mexico. He is enrolled in a program having the admirable goal of earning his Ph.D. (research interest: geology of the Grand Canyon). Kory earned his Bachelor's degree in geology at NAU (as did his mother, Kathy) and he earned his Master of Sciences degree in geology at the Jackson School. Kory is exploring geologic space and time in the Cambrian of the Grand Canyon and the Trilobite Land of Laurentia. Life is good. "And now, an important message to all my family, friends, and foes: KEEP ON FRACKING!!!" says David.

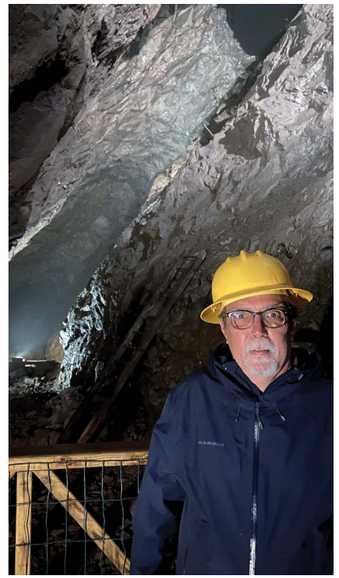
Donnie (Don) Franklin Parker (B.S. '70, M.A. '72, Ph.D. '76) shares, "I wish to thank The University of Texas at Austin and the Department of Geological Sciences (Jackson School) for my educational experiences and the lasting professional friendships established during my tenure as a student. My former teachers, some of whom have passed on, opened up their offices and welcomed a poor student from San Antonio, who was doubtless difficult at times. Among these, in no particular order, were Leon Long, Bill Muehlberger, Keith Young, Steve Clabaugh, Fred McDowell, Dan Barker, R.K. DeFord, Ernie Lundelius, Bob Folk, Earle McBride and Doug Smith. Even when there might have been some conflict, these interactions doubtless improved my character. As Al Scott used to say, "It takes fire to make steel." Note that many of these professors were not in my area of "hard rock" geology. And, of course, many friendships with fellow students were equally valuable. This photo is from the 1975 Geo 660 field camp at the Leary Ranch. From left to right: Bill Muehlberger, Jim Underwood, Don Parker and Rick McCulloh. Note how deeply tanned we were from the 105-115 degree field days in the Marathon Basin!" Don can be reached at Don_Parker@baylor.edu.

John William Preston (B.S. '70) shares, "I'm still working a bit for Hurd Enterprises out of San Antonio. Nancy and I live in Houston, but stay out at my farm in Poteet and do some retainer work with Hurd. So far have dodged the COVID-19 bullet, but have no idea when we will really be able to get back to normal. Like most things, we will probably most remember whatever good comes out of this. As someone who cares deeply for improved understanding amongst the races, I am very hopeful for the first time in my life that there might be some healing in this very old and deep wound." John can be reached at johnp@hurdenterprises.com.

1980's

Carol Swenumson Baker (B.S. '84) writes, "I am still working for ExxonMobil. Like everyone else, mostly working from home this year."

Patricia Bobeck (M.A. '85, Ph.D. '17) writes, "The pandemic quashed my usual summer plans. I had been planning to do research for a book on Paris and enjoy all the delights of France. Instead, I have been enjoying the delights of Austin. During the month of June, that included almost daily dips in Barton Springs. Sadly, that ended when coronavirus cases spiked. So, I have taken advantage of early morning temperatures to explore geology and creeks and to tour historic parts of Austin, while reminiscing about what life was like without air conditioning. I had proposed a hydrogeological tour to France in connection with the 2020 Geological Society of America meeting in Montreal. We were going to visit Henry Darcy and Jean-Baptiste Paramelle sites in Burgundy and southwestern France. Unfortunately, the tour was cancelled when the GSA meeting became virtual. I continue to translate French and Spanish geology and look forward to travel in French and Spanish speaking countries when that becomes possible again. I can be reached at bobeckpa@gmail.com."



Richard F. Carroll (B.S. '80) shares, "I am still doing well and still working the Delaware Basin of New Mexico. We have been drilling pretty much non-stop for the past two years with great results and continuing to add to our drilling inventory. I have no plans to retire because I still love my job. My boys and my dog are all doing very well and are all very independent. I have done some traveling with my girlfriend over the last year or so, including France, Germany and Switzerland. We have also done some road trips through California and the upper peninsula of Michigan. We were able to visit the Quincy copper mine while there. It is on the Keweenaw Peninsula and is famous for the largest deposits of native copper in the world. I thoroughly enjoyed the mine tour and got a couple of great samples of native copper."

David Chow (B.S. '85) says, "After 24 great years at Marathon Oil, COVID/OPEC+ oil price collapse forced early retirement. Hopefully won't stay in retirement long. Looking forward to resumption of senior track & field meets and rec soccer leagues. I'm proud of my daughter, Carla, an RN at a Houston hospital."

Joel Mark Coffman (B.S. '84) writes, "Finally! I was able to transfer from EPA Region 9 to the Region 4 office in Atlanta. After 30 years in Northern California, it was time for a change. I'm still working on Underground Injection Control Wells. We had a new home built and got to move in in July! It is very pretty and nice here, just wish the coronavirus was not in play so we could get out and explore more! Stay safe everyone, and if you are ever in the Atlanta area, look me up! We love being in the South!" He can be reached at coffman.joel@epa.gov or longhornrockhound@yahoo.com.

Gretchen M. Gillis (M.A.'89) was recently elected President-Elect of the American Association of Petroleum Geologists (AAPG) for the 2020-2021 term. She will assume the role of AAPG President for the 2021-2022 term.

William S. (Will) Logan (M.A. '83) says, "Still directing the International Center for Integrated Water Resources Management (ICIWaRM), located at the U.S. Army Corps of Engineers' Institute for Water Resources (Washington DC area) and under the auspices of UNESCO. See https://iciwarm.info. We are also the technical secretariat for UNESCO-IHP's drylands water resources program "G-WADI." Working a lot with developing country universities and water ministries on water resources management assisted by satellite-driven models, and in light of climate change. Amelia and I are still a year away from an empty nest - we got a bit of a late start and then an even

later finish.. Jennifer (27) is happily stuck in Argentina helping keep an eye on my 92-year-old mother-in-law while working on her Spanish. Young William (17) is a techie and a clarinetist, probably in that order. Amelia is a recovering geochemist who now does interior design and absolutely loves it. Let us know if you're in town."

Bruno Maldonado (B.S. '82) says, "Salutations to my alumni friends. This has been an interesting year given the virus (COVID-19 Economic Shock) and downturn in the petroleum industry. I hope all have escaped or overcome the COVID-19. As for my family and I, we have been fortunate to avoid the grasp of the COVID-19. On applying my geoscience, international projects have come to a screeching halt during the COVID-19 lockdowns. In spite of this, I have been able to stay busy domestically. I am having success in exploring along the Texas Gulf Coast. I am not yet ready to retire and still love applying geoscience technology in my evaluation of drilling opportunities. On the personal side, I get to see the grandkids (holding at 4) quite a bit and love the quality time I have been able to spend with them. I hope that next year all returns to normal."

David Noe (M.A. '84) shares, "Well, retirement sure didn't last for long! In following our passions, my girlfriend Jo Ann and I formed a guided tour company in 2018: Colorado Detours. We lead geology and experiential tours out of Paonia, Colorado, in a beautiful but lightly visited part of the state. Our playground includes the Black Canyon of the Gunnison, Grand Mesa, West Elk Mountains, Redstone, Unaweep Canyon, Orvis Hot Springs, an archaeological site in Gunnison Gorge, the Ute Indian Museum, local art studios and chocolatiers, and the wineries and organic farms and orchards in the pastoral North Fork Valley. Wildflower, fall color, rafting, photography, and harvest tours are among our specialties, and oh, that geology!! For the summer of 2020, we are scaling down to provide intimate family and small-group tours. We see amazing sights, learn, have fun, and escape the crowds! Contact us if you plan to visit western Colorado and are looking to have a great guided experience: www.colorado-detours.com! In other news, I am celebrating my 51st year of playing trombone!! I am an active member of the North Fork Community Band. And occasionally I sit in with local blues jams and rock-n-roll bands. Mostly, it's fun to mentor kids and get them excited about playing an instrument. I have an all-plastic, flame-yellow trombone that really catches their attention!" Photo: Dr. Dave Noe and Jo Ann Jarreau own and operate Colorado Detours in western Colorado.

Keith Pollman (M.A. '83) writes, "I've enjoyed two small reunions with UT colleagues this summer. The first was in July when Emil Bramson and his son visited Denver for a soccer tournament. I've attached a photo of (from left to right) Emil, John Curchin, myself, and Roger Wiggin. Emil has not aged a bit - he must have a painting in the attic that ages for him. The rest of us...the years have been kind. John Curchin and I also traveled to Austin in early August to celebrate Allan Standen's 70th birthday. This was my first trip back to UT since 1989, and I was stunned by all the changes on campus and around town. I wish we'd had more time to tour the Jackson School. Of course, we had to go to the Library so that we could view our theses on the shelves. It was great to see Al and other UT alums, including Arten Avakian, at Al's birthday party. I'll try not to let another 30 years elapse before I visit again. Attached is a photo of the Fall 1981 grad student touch football team, which had enjoyed an undefeated season until this game, the league championship, during which we were thoroughly trounced by the Legal Eagles. Pictured from left to right are: Jim Emmett, Dave Palmer, John Curchin, Tim Duex, Steve Cumella's right arm, Rick Kolb, Emil Bramson (back to camera), Chip Oakes, Allan Standen, me, Mark Helper, and Roger Wiggin. You can tell we're grad students by how skinny we all are (were). Thanks to Emil for circulating this last year."

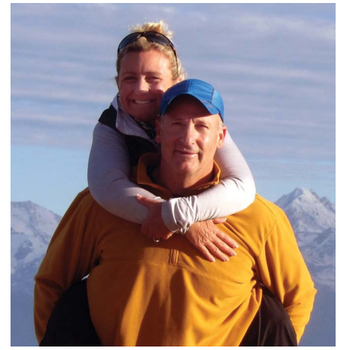
Scott Simmons (B.S. '87) writes, "Well, this year I have certainly become even more familiar with every bit of the Dakota Group forming the ridge behind my house. Geology also still plays a part in my role as the Chief Operations Officer of the Open Geospatial Consortium. I spend a lot of time working with fellow geologists representing research, mapping, and oil & gas organizations in addition to those folks bringing maps to our cell phones. I still pass through some of the 1986 Field Camp locations here in Colorado or in New Mexico and recall great times."

Stephen W. Speer (M.A. '83) writes, "Beam me up Scotty...2020 has been bonkers. Started well...but then both Therese and I got to basically be patient zeros for the Lowcountry regarding COVID-19 back in early March. Fortunately for us we are physically healthy and suffered no real ill effects. Did our quarantine, I lost 10 lbs because we both lost our sense of smell and taste, and we have stayed chipper ever since. Sadly the 10 lbs came back on. Business since then has been, shall we say, "better" for our wedding event space and a planned opening of a new restaurant in June is still up in the air. Timing is everything eh? Oh well, such is life...and we have no complaints as the Lord will certainly see us through this as He always has. Now my biggest issue is to not to be a grumpy old man trying to stay out of jail for not wearing a mask outdoors...and I don't wanna jeopardize my chances at being a Walmart greeter should things really go sideways. All the grandkids (5 stinky boys and one darling girl aged 5 to 14) are doing great and we have a planned mountain retreat in NC at the end of July for the whole family...pray for us. Ok, enough of my frivolity...praying this newsletter finds all of my UT buddies doing well, especially the Dirty Dozen. God rest ye well Al Scott...we are impressed...favorably. Thanks for the memories! Cheers! (Attached photo is of Dave Noe, Steve Speer and Joe Patterson outside the Geology bldg. in August 1983 on the evening I drove to my first job in New Mexico after finishing up my thesis.)

Michael Sweet (Ph.D. '89) says, "Last year (2019) I retired from ExxonMobil after 18 years there and 30 years in the oil industry since I graduated with my Ph.D. from UT. To start my new life, my wife Lily and I took our little tear-drop trailer to Alaska and spent a couple of months in Anchorage, my hometown. It was a wonderful a trip. Using the Rockd app I was able to follow the roadside geology and that was great fun too. After we got back to Texas I started a part-time research position at the Institute for Geophysics, so at least before COVID, I was able to spend more time in Austin. It is a great pleasure to be part of the Jackson School again. I am looking forward post-COVID to dividing my time between Austin and someplace cool during the summers." Michael can be reached at michael.sweet@austin.utexas.edu.

Joseph W. Versfelt (B.A. '84) writes, "After 2 years in Argentina and 8 years in Cairo, Egypt with Apache, I have relocated back to the U.S. In my latest travels, I have been fortunate to visit both sources of the Nile River, the Blue in Lake Tana, Ethiopia and the White Nile at Lake Victoria and Murchison Falls all Lake Albert. Also travelled to the Damaraland inlier in Namibia, Naivasha volcanic complex in the Kenya rift, Olduvai Gorge and Ngorogoro crater (Tanzania), Lake Malawi, and climbed Mt Kilimanjaro. I am now looking to the next professional challenge and adventure."

James Westgate (Ph.D. '88) shares, "I received the Texas State University System's Regents Professor Award in August, 2019 and retired after 30 years of service to Lamar University on Sept. 1, 2019. I can be contacted at james.westgate@lamar.edu."



William Barry Wethington (B.S. '85) says, "Getting ready to retire after a fascinating career developing oil and gas fields around the world. I feel the pull to spend time around my 3 grandkids and more time at the lake house in Virginia after living overseas for 27 years. Upon retirement, I will be joining efforts with a colleague to open a boutique consulting firm (W2) focused on upstream and LNG opportunities. It would be great to touch base with the class of 1985. I truly hope everyone is doing well. I can be contacted at wbwethington@gmail.com."

1990's

Andrew Bowen (B.S. '91) says, "My experience at UT geology was a wonderful period in my life and has enhanced my life immeasurably. Spending time with leading academics who were both humble and could teach allowed me to retain subject matter for over 30 years. We were challenged and encouraged and the hands on and field aspects of the education were awesome. I still stop at roadcuts and those with me are always fascinated by what I share with them. Maybe I will teach

someday. My geology education also gave me a problem solving framework that propelled me to a very successful business career. Geology has also opened up many relationship opportunities for me. I am always amazed at how many people have studied geology or desired to or simply have a rock collection that they want to learn about. Telling people the life story of the rocks in their collection always brings out wide eyed reactions. While I did not make a career out of geology (First stop Consulting Hydrogeologist, Second stop Business, Third Stop Counselor) it has brought much joy to my life. I will return to UT for one final degree—an LCSW to become a counselor to families and individuals. Human behavior has always fascinated me and UT Geo has set me up to be successful in this career as I utilize the problem solving skills with the people who informally come to me today for counseling, I hope one day UT will have a reunion of class years so I can see all the wonderful folks I took classes with and see some of the professors that made my time so fun!" Andrew can be contacted at bowen.andrew@gmail.com.

Danielle Leigh Carpenter (M.A. '96) writes, "Next assignment up for me is GOM Exploration Manager based in Houston,—however, with COVID-19 and working from home we are still in New Orleans and the move is on hold. Will let you know when we get settled in Houston!" Danielle can be contacted at dcarpenter@chevron.com.

Rimas Gaizutis (B.S. '91) shares, "Still employed by REPSOL in Houston as the Global Information Manager for Subsurface Data. My twins start high school this year..."

Mark Buchanan Gordon (Ph.D. '90) says, "I have been living and working in Kuala Lumpur, Malaysia since December, 2019. I work for Beicip Franlab Asia. It has been an interesting experience despite the pandemic."

Christopher Swezey (M.A. '91, Ph.D. '97) and Krystina Scott are pleased to announce the birth of their daughter Evelyn Sofia Swezey on August 11, 2020. Chris continues to work as a Research Geologist with the U.S. Geological Survey in Reston, Virginia. He is currently managing a project focused on geologic mapping in the Great Lakes region of the northern United States.

Justin Zumbro (M.S. '99) currently lives in Rancho Cordova, CA, and can be contacted at justin.zumbro@gmail.com.

2000's

Laura Michelle DeMott (M.S. '07) writes, "In May 2020, I received my Ph.D. from Syracuse University, where I studied the sedimentology and geochemistry of lacustrine carbonate deposits from the Great Basin for my dissertation research. Post-graduation plans were severely hindered by the onset of COVID-19, but I am currently continuing on as a postdoctoral researcher at Syracuse, working on some side projects that were started during my dissertation, while I continue to search for the elusive full-time position."

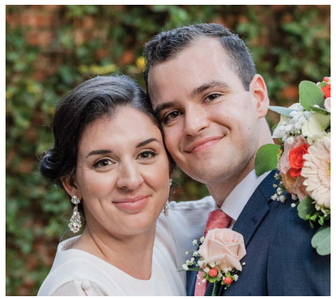
Anne Dunckel (B.S. '09) shares, "After traveling the country and working seasonally with the Forest Service for a few years I have started a permanent position as a hydrologist with the Helena-Lewis and Clark National Forest in Great Falls, MT. Now if I can only remember those cool spots we went to during 660."

Lyndon K. Murray (Ph.D. '08) currently lives in Borrego Springs, CA, and can be reached at lyndon.murray@parks.ca.gov.

Nick Sommer (B.S. '03) says, "After earning my M.S. in Geology from CU Boulder in 2007, I continue to reside in the Denver area and have been working at FourPoint Energy/LongPoint Minerals as a Geologist/Senior Geologic Advisor for the past 6 years. My current focus is mineral & royalty acquisition & divestitures in the Permian Basin. Prior to FourPoint/LongPoint, I worked at Encana for 6 years. My wife Kelli and I have 3 great kids, and life is good. I often think back fondly on my time in Austin at the Jackson School, and can't wait to visit again, hopefully soon!"

Mark Lyle Wiley (B.S. '06) lives in Corpus Christi, Texas, and can be contacted at marklwiley@gmail.com.

2010's



Kaitlin Moran Buzzetto (B.S. '13) was married to Leonardo Santana Buzzetto on July 10, 2020 in Houston, Texas. She currently works as a geologist for Evolution Petroleum and lives in Greenville, Mississippi. Kaitlin can be reached at kmbuzzetto@gmail.com.

Marcus Chroback (B.S. '10) says, "I am excited to start a new role within EOG Resources, as Exploration Manager in our Artesia Division! Hook'em!!"

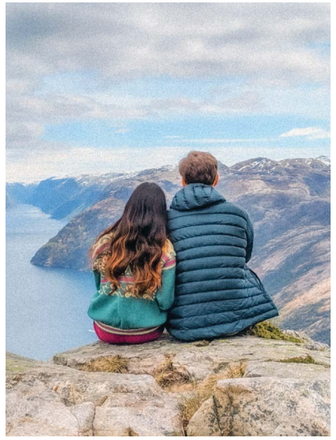
Caroline Nazworth Doerger (B.S. '17) shares, "I graduated in 2019 with my M.S. in Geology from the University of Kansas advised by fellow JSG grad Dr. Mike Blum, and began my career as a geologist with Chesapeake Energy. I also married my high school sweetheart, Ethan Doerger, in Austin last year!"

Aaron Hantsche (B.S. '13) shares, "I finished my bachelor's degree in geology in 2013, and have continued my education in earth sciences. I received a master's degree in geology at the University of Colorado at Boulder, and am now working on my Ph.D. at the University of Geneva in Switzerland, with a focus on hydrothermal ore deposits. During the pandemic, universities around the world were shut down and international conferences were cancelled. In order to help combat this, I joined a small group of geologists to help bring digital, full-length talks to the Economic Geology community. Ore Deposits Hub is a platform that hosts weekly seminars about mining and mineral resources, and has quickly grown to have more than 5,000 subscribers. We broadcast scientific talks to people across the world, helping diversify our community by granting access to ground-breaking research to scientists who may not normally be able to attend professional conferences and seminars. Likewise, we are committed to changing the status quo, making sure to give a voice to under represented researchers and giving a voice to women and people of color in the economic geology community. We plan to continue our efforts even after the COVID-19 crisis subsides, as digital seminars and discussions provide a sustainable method to ensure earth science communication for years to come. It would be awesome to have support from the Longhorn geoscience community as we look to digitalize scientific talks and continue to link the mineral resource sector." Aaron can be reached at aaron@oredepositshub.com.

Bridget Pettit (B.S. '15) and Hal (M.S. '17) Hundley share, "After first meeting in Sequence Stratigraphy back in the Spring Semester of 2015, we got married in October 2019. Bridget has been working unconventionals at ExxonMobil since 2017, and Hal will be starting his MBA at UT this fall after time with Eagle Oil & Gas and Oasis Petroleum. We can be reached at bridgetphundley@gmail.com and halhundley@gmail.com."

Jordan Joyce (B.S. '17) shares, "I'm excited to be starting law school this fall at Lewis & Clark Law School in Portland, OR to pursue environmental law and advocate for environmental justice."

Joshua Ryan Lively (Ph.D. '19) writes, "Following my graduation from Texas in 2019, I served for one year as an assistant professor at the University of Illinois Springfield. I recently accepted an exciting new position as the Curator of Paleontology at the Utah State University Eastern Prehistoric Museum in Price, UT. Our museum is accredited by the American Association of Museums and is an important repository for archaeological and paleontological specimens from state and federal lands in Utah. We house specimens from the San Rafael Swell, the Book Cliffs, and beyond, with particular strengths in the Jurassic and Cretaceous. In addition to my Ph.D. advisor Chris Bell, I owe this amazing opportunity to the training I received with Matthew Brown, Kenneth Bader, Deborah Wagner, Chris Sagebiel, Sebastian Egberts, Ann Molineux, Lisa Boucher, and other staff at the Vertebrate Paleontology Collections and Non-vertebrate Paleontology Lab. For those of you that run field trips to the Book Cliffs, the Swell, and anyone passing through the area, please stop by our museum in Price for a tour! From the Permian through the Eocene, we have rocks in our museum's backyard that are ripe for collaborations with all sorts of Texas geoscientists!"

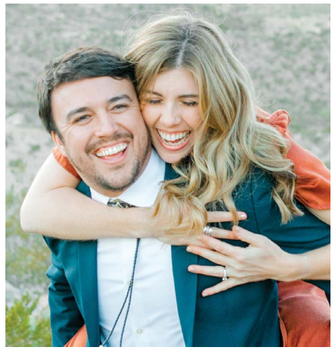


Elizabeth Ashley Menezes (B.S. '18) writes, "Working and living in Norway as a Geophysicist and loving every moment of it!" Pictured: Lysefjord in Norway.

Sinem Okumus (M.S. '15) is an Energy Expert at the Energy Market Regulatory Authority (EMRA) in Turkey.

Sagar P. Parajuli (Ph.D. '16) shares, "I remember my time at UT (2012-2015) with pride. I worked under the joint guidance of Zong-Liang Yang and Gary Kocurek and learned many interesting things about our Earth's environment and climate, particularly about 'dust'. Dust affects air quality. It alters Earth's radiation budget. Without dust aerosols, there would be no rainfall. There is even more. On a larger scale, even the planet Earth is just a speck of cosmic dust. Before life happened on Earth, there was only dust. We came from dust and eventually return to dust. So dust continues to fascinate me. I moved to King Abdullah University of Science and Technology (KAUST) in 2017. My Ph.D. was partially funded by KAUST, and I had visited KAUST while I was still doing my Ph.D.. That is what drives

me here. KAUST is a beautiful place to live and work. From the beautiful coast of Red Sea, I wish my Jackson School family well. I can be contacted at sagar.parajuli@kaust.edu.sa."



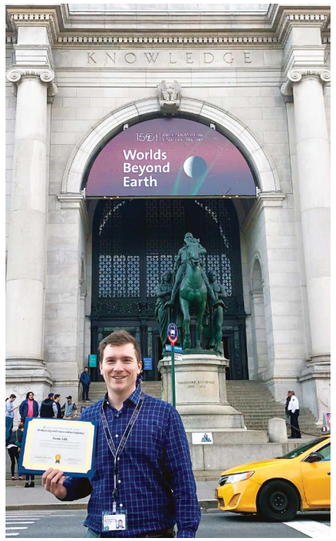
Evan Zachary Pearson (B.S. '10) recently graduated with a Juris Doctor from UT and will begin clerking for Judge Albright in Waco this fall. He will marry his fiance, Carley McCaw, in October. "I hope everyone has remained strong, safe, and healthy during these tumultuous times." He can be reached at ezpearson@gmail.com.

Luis Enrique Arce Perez (M.S. '17) currently lives in Puebla, Mexico and can be contacted at enrique_arce@utexas.edu.

Nataleigh (B.S. '09; M.S. '13) and Nick Perez (B.S. '09; Ph.D. '15) shared this great photo of their son Miles. Although the family lives in College Station, Miles already knows that he should consider the Jackson School for his future geology degree.

Natalie Raia (B.S. '16) was appointed as a Pre-Doctoral Fellow at the Smithsonian Institution's National Museum of Natural History. Following a month-long field season on the island of New Caledonia (SW Pacific), Natalie spent the fall in-residence in Washington, D.C., completing research for her dissertation in metamorphic geology at the University of Minnesota-Twin Cities. Natalie can be reached at raia0003@umn.edu.

Catherine Rohan (B.S. '14) shares, "I recently received a master's in community and regional planning from the University of Oregon and am now working in transportation as an assistant planner with the Albany Area Metropolitan Planning Organization."



Kevin J. Toth (B.S. '16) celebrated his first year at Arcadis in June 2020, specializing in the remediation of per- and polyfluoroakyl substances (PFAS), and spends his weekends as a docent for the American Museum of Natural History in New York City, focusing on biodiversity and conservation. Kevin can be contacted at kjt44023@gmail.com.

Chak Hau Michael Tso (B.S. '12) has successfully defended his Ph.D. on "enhancing the information content of geophysical data for nuclear site characterization" from Lancaster University (UK). His family enjoys living in the beautiful Lake District. He is currently an RA data scientist for the UK Centre of Ecology and Hydrology in Lancaster. You can follow him on Twitter @michael_ts0 or email him at tsohau@gmail.com.

Kelsi Ustipak (M.S. '15) shares, "My career has come full-circle. While I studied at UT, I worked to understand the petroleum exploration industry. Now as an environmental consultant in Minneapolis, Minnesota, I work with pipeline and refining companies to monitor groundwater contaminants and maintain compliance at their facilities. My time in Texas has proved valuable as I understand energy infrastructure and have the best scientific training available in the world, thanks to JSG."

Zehao Xue (B.S. '17) completed his MS in Geology at Louisiana State University during fall of 2019. He is excited to begin his geologist position with the U.S. Geological Survey in Woods Hole, MA.

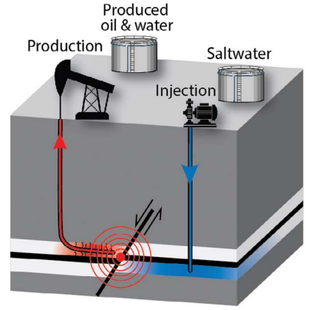
2020's

Kelly Malone (B.S. '20) started working for Golder Associates in their Lakewood, CO, office as a hydrogeologist. She can be reached at kamalone@utexas.edu.

Marlowe Enrique Zamora (B.S. '20) writes, "After having graduated this spring, I will begin studying law at St. Mary's University School of Law this fall."

Friends

Abdulah Eljalafi (current student) shares, "During the past year, I was very fortunate to spend several months doing fieldwork in remote parts of Central Mexico as part of my Ph.D. dissertation. The fieldwork was aimed at collecting pertinent field data for my research on the composition, architecture, and nature of demise of a behemoth carbonate platform system that flourished during the Cretaceous Period. The data collection process included scaling very steep gradients and cliffs to measure sections, collect drone models, sample for petrography and geochem analysis, and even classical contact and structure mapping using high-resolution GigaPan photos and maps. This experience (among others during my time as a Ph.D. student at UT) have helped shape me as a rising geoscientist while quenching my thirst for exploration and also expanded my interest in geology. I hope you enjoy this small glimpse from my adventures in the field and hope it reminds you of all the reminiscence worthy adventures you had during your time as a Longhorn."



Mahdi Haddad (Postdoctoral Fellow) says, "I was inducted as an American Rock Mechanics Association (ARMA) Future Leader last fall. The ARMA Future Leader Program recognizes outstanding early-career members for their contribution to the rock mechanics society and better organizes their voluntary effort to ensure that ARMA has an enduring foundation. Also, Ms. Monica Kortsha, Peter Eichhubl, and I collaboratively developed a press release report for one of my recently published articles, Poroelastic Models for Fault Reactivation in Response to Concurrent Injection and Production in Stacked Reservoirs, accessible for free at *https://doi.org/10.1016/j.gete.2020.100181*. One relevant figure to this press release report is printed here for you to see".

James Sprinkle (Professor Emeritus) writes, "This was my 7th year of retirement as a Professor Emeritus, but not one of the best years that I've ever had. The 1st half of the academic year went fine. I attended the GSA Annual Meeting in Phoenix in November, where I was involved in two poster sessions, one with former Ph.D. student Ron Lewis (1982, now at Auburn), and the 2nd with colleague Tom Guensburg and several other coauthors. In February, wife G.K. and I went on 2 fossil collecting and gymnastic meet trips up to Oklahoma, returning home on March 1st, about 3 weeks before everything got shut down here because of the coronavirus pandemic. We were then stuck at home for the next 6 months, getting out to buy groceries (and a few other items) once or rarely twice a week, and me coming into my office at UT to check e-mails and do research only on Sunday afternoons. However, most of the research projects that had been submitted late last year or were nearing completion were either published early this year, or now have been accepted and put on-line. This includes the Zamora et al. (18 authors) rebuttal paper in Nature Communications about whether an Early Cambrian deuterostome is an echinoderm (we don't think so!), and the Guensburg et al. new Early Ordovician crinoid with unusual arm morphology that was published in the last issue of Journal of Paleontology before it shut down in April. Two other smaller papers, the Zamora et al. new flattened Late Ordovician echinoderm, was accepted after review and is now on-line to be published in Acta Palaeontologica Polonica, and the Blake and Sprinkle new Late Silurian starfish from southern Oklahoma, also survived review and has recently been put on-line at Journal of Paleontology, both hopefully to be finally published later this year. So this has been quite a good year for getting research papers published or about-to-be published."

William I. (Bill) Woods (retired staff) shares, "In December 2019, we returned to El Salvador to take Francisco's Mom to visit relatives. We spent time in our usual favorite places: Juayua, Apaneca, San Salvador, and at the homes of Francisco's Nephews and Nieces. It was a nice, relaxing trip and we really enjoyed seeing everyone again. Now, with the pandemic under way, we are staying home and only dreaming about traveling. I can be reached at billw@utexas.edu."

MEMORIALS

Robert Newton "Bob" Arrington (B.S. '51, M.S. '54) was born in Thrall, Texas, to Millard and Florence Newton Arrington. He attended public schools in Thrall and Granger, Texas, and The University of Texas at Austin where he received a bachelor's and master's degree in geology. He worked for Conoco and Texas Eastern and as an independent geologist in this country, Argentina, Australia and several other foreign countries. He was a member of St. Andrew's Episcopal Church and previously attended St. Dunstan's in Houston since 1972 and served on the vestry during 1973-76, 1988-1990 and as a Junior Warden 1989 and Senior Warden in 1990. Bob was preceded in death by Dotty, his wife of 42 years. Survivors include son and daughter-in-law, Bobby and Ann Arrington; daughter and son-in-law Cindy and Bill Morris; four grandchildren, five great grandchildren and three great great-grandchildren.

Calvin Charles Bench (B.S. '06) was born in Midland on January 17, 1984 and moved with his family to Kingwood, Texas, when he was 4 years old. Cal graduated from Kingwood High in 2002. During high school he founded a popular intramural beach volleyball club called Jaritos, evidence of his enterprising spirit that often had a comedic underpinning. Calvin attended The University of Texas at Austin and graduated with a BS in geology in 2006. After graduation Cal took a winding path, from working as a resort-hand in Hawaii to teaching English in the Czech Republic, South Korea and Japan and finally going back to Czech for another 4 years. In 2011, Calvin returned to the U.S. and worked odd jobs before re-entering UT to earn a BS in Computer Science and an MS in Information Science in 2017. Cal has since enjoyed a successful and promising career with IBM where he brought his creativity, energy and writing skills to enterprise security software. Calvin's life was cut short Saturday morning, February 22, 2020 when he was t-boned by a drunk driver on FM 969. Police on the scene believe that the power of the crash killed Cal immediately. Cal had a colorful manner of self-expression through elaborate costumes that he wore in college, the tattoo art that he crafted over a number of years, and the stories and graphic design projects he dove into. He was relentlessly positive, and towards the end of his life he found common cause with the philosophy of transhumanism, which combined his various beliefs in improving humanity, the transformative potential of technology, and a relentless pursuit of the future. He did everything he could to maintain a sharp mind and healthy body. It is tragically ironic that the life of this man who truly believed that he would live well past 100 years was cut so short. Cal's energy and sense of fun were infectious; some have said that in his short time, he lived the life of 10. Calvin is survived by his parents, David and Claire Gogoel Bench; his sister, Amy Bench (Tim Whitehill), his brother, David Bench (Elizabeth Skadden); nephew, Ellison Whitehill and nieces, Mila Whitehill and Skadden Bench; grandfather, Leonard Bench; and his dog, Parker.

Leon Geddis "Leo" Byerley, Jr. (B.S. '52) died peacefully on February 26 in Midland. He was born in 1926 in Jonesboro, AR and was the only child of Ruth Elizabeth DeGaris and Leon G. Byerley, Sr. His family moved to Midland in 1938 where Leo attended school from the 5th through 10th grades. He transferred to New Mexico Military Institute for his junior and senior years of high school. He was drafted into the Army and served for a year in the 11 Airborne in the Army of Occupation in Japan. Leo married Mary Elizabeth "Betty" Miller on April 23, 1948 and enjoyed 48 years of marriage until losing Betty to cancer in 1996. Leo received a bachelor's degree in petroleum engineering in 1951 and a bachelor's degree in geology in 1952, both from The University of Texas at Austin. Betty and Leo had three children: Ruth Elizabeth, Leon Geddis III, and Daniel Clay. Leo was employed as a geologist in Midland by the Honolulu Oil Corporation from 1952 to 1960. In 1961, he joined with Van Howbert and Don Caussey in a petroleum geology consulting firm. From 1970 on, he worked as an independent geologist. Leo was a member of the Society of Petroleum Engineers, the American Association of Geologists (AAPG), the West Texas Geological Society and the Permian Basin Society of Economic Paleontologists and Mineralogists. He served on committees of the West Texas Geological Society and as a member of the board of the Southwest Section of the AAPG from 1978 through 1979. He also served on the board of Las Manos of the Museum of the Southwest, and he was President of that board when it produced the first SeptemberFest in 1973. Leo was one of the founding members of the Unitarian Church of Midland. Leo was an avid tennis player and for many years was on the courts at the Racquet Club with his doubles partners. Betty and Leo took time in the 1970s and 80s to pursue their interest in world history and archaeology in a series of travels including Mexico, Egypt, Turkey and many sites in the Mediterranean. Leo was a skilled film photographer, a good chess player and a competent computer programmer in the earliest days of the personal computer. He was a truly great father, grandfather and great grandfather. Leo was preceded in death by his parents and his wife Betty. His survivors include his three children, five grandchildren and four great-grandchildren.

Robert Ware 'Bobby' Campbell (B.S. '54), born November 14, 1932 in Galveston to Robert Murphey and Grace Gardiner Campbell, passed peacefully at home on April 9, 2020. His first five years of life were spent in West Texas. When his father suddenly passed, his mother took him on the steam train back to Galveston where they lived in his loving grandmother's boarding house. Polio was the epidemic of the times and his grandmother would take him to Colorado by train each summer to shelter him from the disease that flourished in the hot and humid Galveston weather. He never lost his love for steam engines. A bright child, Bobby was able to skip two grades in school. He found himself in Austin at the tender age of 16 attending The University of Texas at Austin. He studied to be a geologist and after graduation worked several years throughout the oil fields of Texas. When he wearied of that, he moved on to what he was born for: teaching, first in Houston and then Austin. After a short time at Fulmore Middle School in Austin he spent the majority of his teaching career at McCallum High were he was beloved by many of the students. He taught science but more than that he taught life skills, especially to the members of the Rodeo Club which Bobby was the sole sponsor. Besides Bobby's passion for trains he was an avid gardener and a horseman. He bred Quarter Horses and even raced one of his a couple of time at Manor Downs. Later in life he devotedly cared for his mother in the home they shared with a long line of miniature poodles. He was a strong Christian man who spent much time studying scripture. God gifted Bobby many years of life. While Bobby did not marry or have kids of his own, he counted two of his former students as friends so close he lovingly referred to them often and strongly as his sons, Reed Moore and Kevin Faske. He treated their families as his family. He also loved Rae Becker who was his mother's best friend in her later years.

Donald Booth Clutterbuck (M.A. '58) passed away on July 5, 2020 in Houston. He was vibrant until his very last moments, enjoying lunch with his family, drinking wine, talking about a book he was reading, his time in the Navy, and celebrating the Fourth of July. He collapsed from what is believed to have been a heart attack. Don was born on March 3, 1929 in Beaumont to Donald James and Catherine Booth Clutterbuck. Don spent his formative years in Beaumont and Tulsa, OK. He graduated from Marquette High School in Tulsa in 1947, where he was class president for three years and was remembered for his ready smile and friendliness. In 1951, Don graduated from Marquette University in Milwaukee, WI. Following several months as a roustabout in the oil fields of West Texas, he then reported to the Navy Officer Candidate School in Newport, RI. Don served 3-1/2 years in the Navy aboard the Destroyer Escort USS LeRay Wilson, based out of San Diego. He completed two 6-month deployments in the Pacific, including making port in the Philippines, Hong Kong, the South China Sea, and Pearl Harbor. Don rose to the rank of Lieutenant JG and served as Chief Engineer on the ship. Early on in San Diego, Don met LaDonna Marie Bicknese, who had moved to California to teach elementary school. They married in July 1954 on the Naval Air Station in Coronado, CA. Following his discharge from the Navy, the couple moved to Austin, where Don earned a master's degree in geology at The University of Texas at Austin. He then went to work for Shell Oil Company for 10 years, living with LaDonna in Midland, Del Rio, and Corpus Christi, Texas; and Santa Fe, New Mexico. He later enjoyed a long career working for several independent oil & gas companies, ultimately serving in Senior VP, President, and COO roles with Inexco, McCormick, Tipperary, OXOCO, RPI and AFG Energy. Don retired in 1999 and spent much of his free time volunteering at the Houston Museum of Natural Science. Don was an enthusiastic docent, sharing his love of geology at his much-loved Weiss Energy Hall and in the Cullen Hall of Gems and Minerals, and educating himself and the public about special exhibits as diverse as the Titanic, the Vikings and the world's largest Russian Faberge Egg collection. His 15 years of volunteer service there won him many accolades and friends with whom he had engaging lunches. Don was a longtime member of both the Houston Geological Society and the Petroleum Club, where he served on the Board for many years as well as a term as President. He also greatly enjoyed his many years on the tennis courts, often with his longtime friend Charlie Church. Don was particularly proud of his sons, John and Jim. Favorite memories include making peach ice cream in the garage together, going on hunting trips, playing tennis, regular weekend waterskiing outings to Lake Somerville and Lake Travis, and supporting their youth sports. Don also loved giving "buzz cuts" with a hair trimmer on the backyard patio and supervising their teenage chores of mowing the yard and tending to the home landscaping. Don did gain an adopted third "son" when John and Jim went off to school: a standard poodle named Sargent. As the Sargent years came to an end, Don started welcoming his beloved grandchildren into the family. Don was an avid reader of history, mysteries and thrillers. The Clutterbucks moved to the Hallmark in 2012, where Don developed many new dear friends. Don quickly assumed various community duties, including serving a few terms as President of the residents' association and as Treasurer of the semi-annual employee gift fund. LaDonna was truly the love of Don's life. During their 63 year of marriage together, they enjoyed raising their two sons, playing gin rummy, tennis, waterskiing and boating, dinner and dancing at the Petroleum Club, taking driving trips across Texas, travelling to Hawaii and Italy, and cruising Alaska and Northern Europe. Don was preceded in death by his wife LaDonna, his parents, his cousins Barbara and Travis Parker, and his daughter-in-law Shelley Day Clutterbuck. He is survived by his sons John (wife Anne) and Jim, and his beloved grandchildren, Caroline, William, Miles and Zoe.

Arthur Leroy Cochrum (M.A. '52), passed peacefully into the arms of his Lord on October 28, 2019 in Canyon Lake, Texas. He was born in Kingsville, Texas, January 5, 1925, the son of Allen C. and Rosa K. Cochrum. He was preceded in death by his parents, his brother Allen, his beloved wife Nancy, son Arthur Leroy Cochrum, Jr. and daughter Cathy Caroline Cochrum Vann. He is survived by his sons John (Blanca) and Andy (Mary) and son-in-law Rodney Vann. Arthur had twelve grandchildren and numerous great-grandchildren. Arthur grew up in Houston and was a graduate of Lamar High School. He then went on to graduate from Texas A&M University in 1945 where he earned a degree in geological engineering. He served in the Navy and upon his discharge he went on to further his education by earning his Master of Science in geology from The University of Texas Austin. He was an Aggie through and through. He retired from Humble Oil and Refinery (Exxon) where he worked for 27 years. Arthur realized his dream of retiring to Canyon Lake in 1999 to the house he designed. He and his sweetheart Nancy would sit on the back porch and watch the Guadalupe River and loved to entertain family and friends. He was very active in the Canyon Lake community and a member of Chapelwood United Methodist Church, Houston and North Shore United Methodist Church, Canyon Lake.

Richard Dale "Ricky" Cook (B.S. '76) was a longtime resident of Houston. He lived a full and purposeful life from 7/17/52 to 8/11/2020. Ricky graduated from The University of Texas at Austin with a degree in geology. He settled in Houston and started his first and last job as a geologist at Pennzoil, later becoming Devon Energy. He was a loving and devoted father and recent grandfather who always made spending time with them a priority. Ricky made friends wherever he went and had many interests including live music, the Hill Country, happy hours with friends, music cruises, walking his dogs, spending time in prayer, and playing his trumpet. One of his greatest joys was playing trumpet in several bands including the Lone Star Symphonic Band. He is survived by his son Cody Cook, brothers David and Brian, grandson Jackson, and girlfriend Kaydee Cooper.

William Grey Darsey (B.A. '57) passed away July 16, 2020. He was born July 18, 1936 to W. G. Darsey, Jr. and Roberta Deerman Darsey in Grapeland, Texas. He is survived by his beloved and loyal wife Shirley W. Darsey, his children Paige (Mike) Lee; Revill (Warren) Bayer; W.G. (Rig) Darsey, IV; Tamara W. (Steven) McBride; and his grandchildren: Catherine and Courtney (Eddie) Lane; John, Brooks, and Robert Bayer; and Logan McBride. He is also survived by many nieces, nephews and friends. He earned his bachelor's degree from The University of Texas at Austin, and did graduate work at the University of Oklahoma and Rice University. He also took extension classes from the Wharton School of Business at the University of Pennsylvania before embarking on a successful career as an independent geologist. Early in his career, he negotiated eploration licenses in the Middle East, the North Sea, and the German Baltic Sea. For twenty-three years, Mr. Darsey worked the Frio and Miocene trends of South Lousiana and the Hosston and Cotton Valley trends of North Lousiana, prospecting for oil and gas. Since moving to Houston in 1986, he worked the Frio, Miocene, and Wilcox trends of South Texas while assembling drilling deals for sale to industry operators. He enjoyed hunting, fishing, the Texas Longhorns, and golf. His book of poetry, "The Mist: A Collection of Poems About Nature, Philosophy, and Spirituality," was published in 2007.

Ralph Charles Duchin (M.A. '55) of Tucson, Arizona, and Houston, Texas, passed away on May 25, 2020. He was born in New York City to the late Minnie and Jacob Duchin. Ralph graduated from Stuyvesant High School, Brooklyn College and completed his master's degree in geology from the Jackson School of Geosciences at The University of Texas of Austin. He is survived by his wife of 60 years, Sally Pomeranz Duchin; his daughter, Susan Jo Duchin; his sister, Barbara Duchin and his brother, Hal Duchin. Ralph was a beloved and adored husband, father, brother and friend and will be truly missed.

Eddie D. Dunagan (B.S. '53) passed away May 27, 2020 in Austin after a twenty-two year battle with Parkinson's disease. He is survived by his wife of 63 years, Virginia Coy Dunagan; sister, Bonnie Dunagan Burkett and husband, Lester; son, Ronald and wife, Sheila; son, Richard and wife, Jennifer; son, Robert and wife, Rhonda; son, Roger and wife, Dana; fourteen grandchildren and seven great-grandchildren. He is preceded in death by his father, Dell; mother, Christine; brother, Randall and daughter-in-law Diane Dunagan. Ed was born January 20, 1932 in Gilmer, Texas, to Dell Owen and Christine Hurt Dunagan. He received a bachelor's degree in geology from The University of Texas at Austin in 1953 and a master's degree in business from George Washington University in 1969. Ed was sworn in as an officer in the United States Air Force in 1953 and began pilot training. While on assignment at Larson AFB in Moses Lake, WA, Eddie met Virginia Coy. The two were married April 19, 1957. Ed was a pilot in the 4080th Strategic Reconnaissance Wing, Strategic Air Command, that operated U-2 spy planes out of Laughlin AFB, Del Rio, Texas,and Davis-Monthan AFB, Tucson, AZ in the late 1950s and early 1960s. This unit was instrumental in providing reconnaissance of the island of Cuba for President John F. Kennedy during the historic Cuban Missile Crisis in 1962. For his participation, Ed earned the Distinguished Flying Cross. He also served as an A-37 pilot in Vietnam. Ed retired from the Air Force as a Colonel in 1979. After retiring from the Air Force Ed started a new career as a financial advisor with several stock brokerages, beginning with E.F. Hutton and concluding with Smith Barney. He also was a partner in a road construction company, Triple R Contracting with his youngest son, Roger. Ed's passion throughout his life was his Christian faith. He was a member of the Church of Christ in Del Rio; Tucson; Prattville, AL; Honolulu; and finally in Austin at the Westover Hills Church of Christ. His struggle with Parkinson's disease did not keep him from attending worship service with his Christian family.

Laura B. Evins (B.S. '79) was born in Houston, Texas,on March 28, 1957 and passed away on April 5, 2020. Laura was a graduate of The University of Texas at Austin where she received a bachelor's degree in Geophysics. She worked many years in the geophysics field in support of oil exploration, and was a member of the Society of Exploration Geophysicists. As part of her career, Laura traveled all over the world, including living in London, England for several years. In her younger years she enjoyed sailing on Clear Lake. Preceded in death by her parents, James Jerry Evins and Anna Elizabeth (Matzke) Evins, Laura is survived by her brother, Stuart Alexander Evins, brother, James Barry Evins, and sister, Shawn Evins Kelm. She is also survived by a nephew, James Stuart Evins, and nieces, Melody Ann Kelm and Heather Marie Kelm.

George Harold Falk (B.S. '57) peacefully passed away on March 27, 2020, at his home in New Braunfels, Texas. George was born on April 18, 1935 in San Antonio to Faye and Carl Falk, Sr. George was the beloved husband and best friend to his wife of 47 years, Dulane Falk (Bettge); devoted father of George Falk Jr. (wife, Lesa), Erin Falk Ackerman (husband, Howard), Leigh Falk, and Laurie Falk; loving grandfather of Meghan Ackerman, Natalie Ackerman and Katy Murch. George is survived by his brother, Carl Falk, Jr. (wife, Patricia) of Corpus Christi. George graduated from Jefferson High School in San Antonio and The University of Texas at Austin with a degree in geology. Over the course of his life, George worked as an oil landman, business owner, investor, and real estate broker. George loved to travel with his family and friends, and his favorite spots were New Orleans, Santa Fe, and any location that had a beach and water. Always loved, he will be missed by his family and friends. His was a life well lived!

William "Bill" Alvis Faubion (B.S. '50) passed away August 18, 2020, just days before his 93rd birthday. Bill was born in Everman, Texas, to Alvis and Wanda Faubion and spent his childhood in West Texas. After serving in the navy at the end of World War II, he attended The University of Texas at Austin and graduated in 1950 with a bachelor's degree in geology. Bill again served a stint in the armed forces until 1954. He then began his career as a geologist with Continental Oil Company. In 1959, Bill joined Ashmun and Hilliard Oil Company in Midland, as a subsurface geologist. It was there that he met the love of his life, Dorothea Varisco, and they married in 1961. Bill and Dorothea had many happy memories of those early years and made lifelong friends. In 1962, Bill began work with John Ashmun at J.B. Ashmun Inc. and Wainoco Oil and Chemicals and moved the family to Calgary, Canada in 1966. After a brief move to Denver, CO, they made their final move in 1973 to Houston where Bill served as Exploration Manager, Executive Vice President and Board Member for Wainoco Oil and Gas. From 1985 to 2005, Bill continued work as an independent geologist. Bill will ultimately be remembered for his sense of humor, the love for his family, and participating in almost any activity outdoors. He enjoyed fishing, hunting, and working on his ranch in Hockley. He was an avid skier and golfer. He could play the guitar by ear and loved to sing "King of the Road" and "Me & Bobby McGee". He was humble, kind, always first to laugh, and treated everyone around him with respect. Bill is survived by his wife, Dorothea, his children, Annette Faubion Stephens (husband Rand) and Dr. William Alvis Faubion, Jr. (wife Stephanie); and his grandchildren, Ann Katherine, Samuel William, Louise Parsons, Madeline Grace, Erin Annette, Laura Lee, Kari Ann, and Dorothea Cantrell.

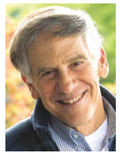
Walter Keene Linscott Ferguson (B.S. '56, M.A. '58) passed away peacefully on Dec. 31, 2019. Keene was born in Houston on April 28, 1934 to Harry Weidel Ferguson and Josephine Linscott Ferguson. He attended St. John's School in Houston where he graduated in 1952 as head prefect. He attended Princeton and then The University of Texas at Austin, graduating from UT with a bachelor's degree in geology. While at UT, Keene was a member of the Kappa Sigma fraternity where he made many life-long friends. He later attained a master's degree in geology (1958) and a doctoral degree in History (1969), both also from UT. Keene started his career in the corporate world, working for Humble Oil as a geologist. But he decided early on that teaching was his true calling. He was an assistant professor of history at Our Lady of the Lake in San Antonio on two different occasions in the 1970s and 1980s. He also taught history and social studies at St. Stephen's School in Austin, and later for many years at Hill Country Middle School in Westlake. In his later years he taught at the Sage Program at UT. He also worked for the Bureau of Economic Geology at UT. Keene wrote books and made maps. He was an explorer. He was a talented wood carver, stone cutter, bead weaver, jewelry maker, furniture maker, bee keeper, cook, baker, book collector, and bird watcher (during which he spent many enjoyable times with his son Jamie). He even constructed his own BBQ smokers. Keene was a naturalist and loved exploring the great outdoors. He and his children spent

many summers camping all over the Southwest, from Enchanted Rock to the Gila National Forest in New Mexico to the Los Piños River at Cumbres Pass in Colorado. Birding books and binoculars were always nearby. The place he revered most was West Texas, spending time on his brother-in-law's ranch outside San Angelo and at his own home in Fort Davis. He also owned a home in Port Aransas where he would bird watch and spend time with his family on the beach. Never one to take to flying, over the years he drove everywhere he went in pick-ups, vans, and Suburbans, almost always with a carload of his kids and their friends. As an outgrowth of these road trips, Keene and a friend authored one of the earliest guides to Texas Roadside Historical Markers in 1977. Keene was kind, humble, and generous with his time. He liked a good party with friends. He was always upbeat with a smile in place below his kind blue eyes. Keene is now up at that big party in the sky, saying, "Beautiful!" Keene was preceded in death by his parents, his sister Jolyn, his son Jamie, his first wife Hallie—the mother of his four children, his second wife Patricia—the mother of his two step-daughters, the joy of his last nine years, Lynn Baker, and his special friend and childhood nanny Myrtle Johnson. Keene is survived by his sons: Scott (wife Kelly) and Jody (wife Mila), by his daughter Hallie (fiancée Stuart), by his two step-daughters Mallory Leitner and Ursula Comeaux (husband Chris), by his ten grandchildren (Rachel, Walt, Claire, Max, Hallie Fei, Alex, Paulina, Phillip, Will and Avery), by three great-grandchildren (Hallie, Neely Wynne and Paul), and by his sister Nancy Haywood (brother-in-law Ted).

James Roy Garrison, Jr. (B.S. '76, Ph.D. '79) passed away May 9, 2020 at his home in Corpus Christi. James was born February 15, 1952 in Fort Worth to James and Mattie Garrison. James was a 1970 graduate of Atlanta High School. Upon graduation he attended The University of Texas at Austin where he received his Ph.D. in geology May 19, 1979. After graduation James accepted a research associate appointment at the University of Tennessee where he was involved in research of the moon rocks brought back to earth by Apollo 16 and 17. James worked in the oil and gas business for many years and in his later life as a consultant. He taught at the University of Oklahoma, Texas A&M Corpus Christi, and University of Texas Galveston. James loved to be out in the field doing research. James loved astronomy and considered becoming an astronomer, but chose to become a geologist instead. He collected rocks his entire life. His first love, however, was always for the ocean. He spent his last years living on the beach in Corpus Christi and Galveston while teaching and researching shoreline erosion. He was preceded in death by his parents. James is survived by one daughter, Emily Balson and husband Josh Balson; one son, William Garrison; three grandchildren, Dax Garrison, Jack Balson and Willa Balson; and one sister, Carolyn Garrison Vernon and husband, Paul.

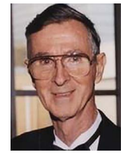
Wyeth Leonard "Boots" Goode (B.S. '53), was born July 12, 1929 in San Angelo, Texas, to parents Homer and Jessie Lea Goode. He grew up in San Angelo and graduated from San Angelo High School and received an Associate's degree from San Angelo Junior College. He graduated with a bachelor's degree in geology from The University of Texas at Austin in 1953 and did postgraduate work at UT and Texas Tech. From 1946 to 1952, he served in the Naval Reserve and on October 31, 1952 he married Louise Gayer Goode, also from San Angelo. From 1953-1970, he worked for Marathon Oil Co., spending 1956-1960 in Guatemala and 1960-1962 in Libya. The Goode family moved to Midland in 1962. In 1970, Mr. Goode opened an office for Amarillo Oil Co. and Pioneer Natural Gas in Midland and served as District Manager until 1977 when he resigned to become an independent consulting geologist. Mr. Goode was a member of the Wildcatters, AAPG (American Association of Petroleum Geologists), the West Texas Geological Association and the IPAA (Independent Petroleum Association of America). He was qualified as a Certified Petroleum Geologist and served as an expert witness in legal court cases. In 1983, he served as President of the Board of Directors of the Midland Country Club after being on the board since 1981. He was a member of the First Baptist Church and an active supporter of Wycliffe Bible Translators Inc. His sons, William and Richard, his parents and his brother, Buddy Goode, preceded him in death. He is survived by his wife of 67 years.

Thomas E. Green, Jr. (M.A. '56) passed away on Wednesday, July 1, 2020. He is preceded in death by his wife, Katherine Prattes Green and his brother Paul M. Green. He was born in Butler, Pennsylvania to Jessie MacDonald and Thomas E. Green Sr. on September 9, 1929. The Green Family moved to San Antonio in 1940 when Tom was 11 years old. Tom graduated from Alamo Heights High School in 1947 where he was voted "Most Popular Senior" and played football for the Mules. After high school, he enrolled at The University of Oklahoma to pursue his undergraduate degree, during which time he was called to serve his country in the Air Force in the Korean War. Upon his return he completed his degree at OU and then joined his brother at The University of Texas at Austin for his graduate degree in petroleum geology. In his early career he worked as a petroleum geologist for various companies before setting out on his own with his longtime partner Bob Staewen. This was not only the beginning of a successful venture but a lifelong friendship. Tom loved his colleagues in the oil and gas business and was active in the Petroleum Club and many other industry organizations. Tom married the love of his life, Katherine, and they were blessed to enjoy over 60 years of marriage together. Having been separated by less than a year, they have never been apart on their anniversary which we know they celebrated together on July 3rd in heaven. "Gran-D", as his granddaughters knew him, loved having them over for swimming at their home, weekends in Port Aransas and most of all watching all of their school and sporting events. Golf was a favorite hobby, which he taught to his children at a young age. He enjoyed many golf matches with his buddies (for maybe a small wager). Tom is survived by his children, Susan Green, Tommy Green and his wife Carrie, Granddaughters, Caroline, Katherine and Elizabeth, and sister-in-law, Cathy Obriotti Green.



Redge Larry Greenberg (M.A. '73) passed away on December 8, 2019. Redge leaves his two children - Tiffany Purcell (Hap) and Aaron (Sarah), and his three grandchildren - Jack and Skyler Purcell and Arthur Greenberg. He was a devoted husband to his wife of forty years - Linda Greenberg, who died in 2013. Redge and his late wife moved from Austin to Durango in 1999. For the past six years, he had been the beloved second-life partner of Mary Nowotny. Redge's life was full of family, learning, and adventure. He grew up in Reading, PA, and reached the rank of Eagle Scout. Shortly after moving to Los Angeles at age 16, he saved up money from his job at a local gas station, and earned his pilot's license. He received his undergraduate degree from the University of Arizona, and then went on to earn two master's degrees and completed course work for a Ph.D. in geology and geophysics at The University of Texas at Austin. For many years he worked with Hupecol, an energy exploration and production company, developing 3D seismic interpretive maps identifying potential sites for development in Colombia, Mexico, Italy and New Zealand. He always loved the learning process, which lead him to become a part-time professor of mathematics for ten years at Austin Community College. Redge absolutely loved the outdoors. He was a certified SCUBA diver, a BA hiker, traveler of the world, a bare boat sailing captain, and had ninety-nine parachute jumps (ninety-eight without mishap). An avid aviator, Redge bought his first airplane at age 18 and flew private planes for nearly ten-thousand hours for pleasure as well as service to local search and rescue efforts. Assembled in his garage, he was one of the first owners of a kit-built SubSonex jet, which he flew from Durango-LaPlata airport. He enjoyed performing many aerobatic maneuvers, at a safe height, of course! He was an active member of EAA (Experimental Aircraft Association) based at Animas Air Park, and flew for many years at the local glider port. Redge was born to Ruth and Robert Greenberg on September 9, 1949, in Houston. In addition to his children and grandchildren, he is survived by his younger brother Gary Greenberg and his younger sister Laurie Greenberg.

Kim L. Lancaster (B.S. '81) passed away January 7, 2020 in Dallas from colon cancer. He was born November 13, 1953, in Weslaco, Texas. After attending Weslaco schools, Kim enlisted in the U.S. Air Force and served overseas. He attended The University of Texas at Austin and graduated with a degree in geology. He worked in the oil industry in West Texas and New Mexico for City Services and Occidental Petroleum. In retirement, Kim lived in Dallas and San Miguel de Allende, Mexico. He was active in the recovery community and was a friend and counsel to many others. He was a voracious reader, a student of history, and enjoyed playing the guitar. He spent his days in Mexico zooming around San Miguel on his motorcycle, grilling outdoors for friends, and tending to a rooftop patio full of native plants. He was devoted to his pets, a long line of dogs and cats who returned his adoration. Preceded in death by his father Rogers Lancaster and brother Rogers Hall (born Rogers Lancaster, Jr.). Survived by his mother Betty McDaniel Lancaster; sister Karen McCutchin (Jerry); brother Kermit Lancaster (Sarah); sister Kris Marsh (Chuck); and sister Kay Fulton (Duncan).



Sabin William Marshall (B.S. '52) passed away peacefully on January 8, 2020. Sabin was born on October 15, 1928 in Houston, attended Lamar High School and was a proud graduate of The University of Texas at Austin with bachelor's degree in geology, class of 1952. He enjoyed a long career as a geologist with Texas Gas Transmission and was an active member of the Houston Geological Society, serving as its President in 1975. Following a European tour of duty with the U.S. Army, Sabin married the love of his life, Mary, in 1958 and together they raised four children. Sabin and Mary were founding members of St. Thomas More Catholic Church, where he served as an usher for many years. Sabin was a devoted family man, playing catch in the backyard, coaching little league, taking us to Astros games in the Dome, Indian Guides, and serving as a Scoutmaster. He taught us about fairness, doing the right thing, paying yourself first but always making room for charity, and having compassion for others. Sabin loved the outdoors and travel, taking the whole family on a tour of the country by car every year with the trusty pop up camper in tow. Yellowstone, the Dakotas, Grand Canyon, Monticello, Mt. Vernon, Colorado, New York City, the KOA in Phoenix, and last but not least, driving from Houston to San Francisco and back. His fondness for camping didn't rub off on his children in adulthood but we're all grateful for the opportunities he gave us- to see the country, to meet people different from ourselves and experience things we weren't used to; scary but wonderful at the same time. Sabin was predeceased by his loving wife of 59 years, Mary, brother, Ralph Marshall, and brother in law Frank Goban. He is survived by sister in law Mildred Goban, children and spouses David (Marlene), Brian (Rachel), and Darin (Kristen) Marshall, Madeleine Ellard (Jeffrey), grandchildren Chris, Henry, Brendan, and Lillian Marshall, Elaine Ellard, Emily Lessner (Matt), and step-granddaughter Maggie Jashinsky (JD).

Clyde H. Moore (M.A. '59) passed away on July 1, 2020.

Richard Alan Nicholas (B.S. '68) passed away on November 22, 2019. He was born in St. Joseph, MO to James and Helen (Robinson) Nicholas. Richard was a graduate of McCallum High School in Austin. He received both his bachelor's and Ph.D. from The University of Texas at Austin and his master's degree from Southern Illinois University in Carbondale, IL. Richard worked at several universities around the country before coming to Texas Woman's University in Denton in 1996. He served as the Vice President for Student Life until his retirement in 2014. Richard married his college sweetheart, Anne, in 1970. They have one daughter, Laura. Their beloved family includes Laura, her husband, Brian Hupach, and two beautiful granddaughters, Brianna and MaKaya. Other family members include Anne's siblings and their families, and many cousins, nephews, and nieces. Richard loved his university and the time he spent mentoring students. He proudly watched successes of his students around the country. In his retirement he enjoyed time with hobbies including traveling, collecting gems and minerals, philatelic stamps (particularly early Hawaii), and growing and hybridizing African Violets. He served as President of the African Violet Society of America from 2017-2019. He and Anne shared all these activities and relished their quiet life at home together. In addition to his family, he loved his dog and at least one canine companion always enriched his life. Richard will be remembered for his quiet wit and humor, dignity, respect, wisdom, and his love of life.

Horacio Oliveira (B.S. '50) passed peacefully on July 2, 2020. He finally got his wish of joining our beautiful mother in heaven. He spent many evenings visiting friends in hospitals and attending funerals. He served his country with great pride, and he particularly honored his fellow veterans that preceded him in death by formally saluting them at their caskets to pay his respect for their service. Dad was born and raised in Benavides, Texas, and graduated from there in 1943. When WWII broke out, he enlisted in the Army as part of the 11th Airborne. After being wounded and spending time in a field hospital on Biak Island, New Guinea, he earned a Purple Heart, plus many other medals of honor. Because of his wonderful humility, he never spoke of his valor and heroism. We only found out about it after going through his paperwork. He returned from the war to marry his bride, Delia Salinas, in Ramirez, Texas. They moved to Austin where he attended The University of Texas at Austin on the GI Bill earning dual degrees in petroleum engineering and geology. It was not easy in those days for Hispanics to break into the world of engineering, but he worked hard to support his ever-growing family and finally landed a job with the Civil Engineering Department at the City of Corpus Christi. In his spare time and always preferring to work outdoors, he studied hard to become licensed as a Registered Professional Land Surveyor. It paid off; he was the first Hispanic in Texas to pass the RPLS exam and soon started his secondary business of Oliveira Land Surveying Company. He worked seven days a week, five at City Hall and the other two for his own company. Eventually, Dad was named head of the Land Surveying Department for the City of Corpus Christi. He retired from that job after 35 years with the City, but continued to work at his own business, which he managed until his death. Always concerned for the employees, Dad and four others, formed the City Employees Credit Union, because they saw a need for a credit union for City workers. Eventually the Credit Union grew to what it is now: Two branches with the new name of Texas Bridge Credit Union. Dad's beautiful heart was broken for the first time when his oldest and only granddaughter, Cathy Hernandez Lowe, passed away in 2000. Then he died a little more when his beloved son, Lacho Oliveira, Jr., passed away in November 2017. Then the final blow was when his beautiful wife, Delia, died three months later in February 2018. Others who preceded him in death were his parents, Corando and Maria de Jesus Oliveira; his brother, Armando Oliveira; his son-in-law, Rolando Garza; his daughter-in-law, Margaret Oliveira; and his children, Javier and John Albert, who died a few days after birth. He is lovingly survived by his daughters, Dolores (Pete) Gonzalez, Noela Oliveira Garza, and Denise Oliveira. He is also survived by his grandchildren: Marcos (Denise) Oliveira, Dusty (Cecy) Oliveira, Chuck Oliveira, Michael (Debbie) Hernandez, John Eric (Robin) Hernandez, Steven Garza, Chris Garza, Sergio Gonzalez, Javier McCaskill, Cody McCaskill, and Andy McCaskill; as well as nine great-grandchildren. Dad is also survived by his beloved little sister, Lydia Oliveira Olivarez. A special thanks to grandson, Steven Garza, who devoted so much of his time to his grandfather in his final years.

Arlis B. Parkhurst (B.S. '62) passed away on July 2, 2020. Arlis was born in Seminole, OK, on January 17, 1937, to Vera Marie and Arlis Beckham Parkhurst. The Parkhurst family lived in Cushing, OK, where Arlis's Father was employed as a pipeline engineer for Shell Oil Company. The family moved to Colorado City, Texas, in 1947, when Arlis was in grade school. He excelled at sports, especially football. Arlis graduated from high school in 1955 and entered The University of Texas at Austin on a full athletic scholarship. At UT, Arlis successfully balanced the rigors of obtaining a degree in geology with the endeavors of playing football and enjoying the many life-long friends he made as a member of the Phi Gamma Delta Fraternity. He played on the UT Longhorn football team for three years, wearing No. 55 on his jersey. He became close friends with Coach Darrell Royal, a friendship that lasted through the years. Arlis loved to tell the story that when he returned to UT for his last season, 25 pounds overweight (due to a summer of hamburgers, french fries and fried pies), Coach Royal said: "Arlis, I never had a captain that didn't make the traveling squad." Arlis got the message and was promoted back to first string for the first game (25 pounds lighter). He had a stellar season (except for the loss of "some teeth" in the Rice game), and was selected for the 1958 North-South Shrine Bowl played that year in the Orange Bowl in Miami. Upon graduation from UT, Arlis enlisted in the U.S. Marines, serving six months on active duty and six years in the Reserves. Arlis moved to Dallas in 1961 and was employed by the Henry S. Miller Company, learning the ropes of being a real estate broker. Arlis subsequently struck out on his own, working as a broker on many major transactions, especially in undeveloped land. In 2003, Arlis met Beverly Ray through mutual friends in Newport Beach, CA. They were married on Dec. 31, 2005. A few days later, the newlyweds and their guests viewed UT's victory over USC in the Rose Bowl. Beverly and Arlis moved to Dallas in 2007. He cherished his dogs, especially "Big Boy," a Great Pyrenees sheep dog. The Parkhursts and their pets managed to survive the destructive 2019 tornado, which went right over their home. A highlight of their time together was a weekend visit to Austin in April, 2015, attending a Phi Gam class reunion, touring the new buildings on campus and sailing the waters of Lake Austin aboard the Riverboat Commodore, the same sternwheeler on which Arlis and his friends often sailed when they were in school. Arlis never forgot his West Texas roots. He established The Arlis Parkhurst Endowed Scholarship at the Texas Interscholastic League Foundation which provides tuition grants with an emphasis on trade and technical schools for students from smaller West Texas communities. Arlis' scholarship is currently funding tuition grants to 20 students. Arlis is survived by Beverly and his nephew, Scott Winton and wife, Jenny.

Gerald "Jerry" Sweet Pitts (B.S. '54) passed away on August 14, 2020. Jerry was born to Laura V. and Allen F. Pitts on September 24, 1932 in Fort Worth, Texas. He was raised by his mother in Fort Worth. He graduated from Paschal High School in 1950 and The University of Texas at Austin in 1954 with a bachelor's degree in geology. After graduation, he entered the U.S. Navy serving on board the USS Cogswell (DD 651) in the Pacific Theatre. On August 22, 1953, he married his high school sweetheart, Carol Sweatman, whom he cherished and adored. People often spoke of how much they were amazed at his deep love for his wife of 67 years. In October, 1956, Jerry moved to Midland to work for Humble Oil and Refining Co. During his employment with Humble, he worked as a surface geologist, core drill geologist, and production-exploration geologist at various towns in the Permian Basin returning to Midland after each assignment. In 1966 he became an independent geologist. In 1982, with the help of Greg, his oldest son, he formed Pitts Energy Company. His other two sons David and Steve joined the company shortly after Pitts Energy was formed. He served as President of Pitts Energy Co. until January, 1999 when he officially retired. He has continued in an advisory capacity until his death. Jerry was a life-long member of the United Methodist Church. He was a member of the AAPG, WTGS, SIPES, Longhorn Foundation, Life Member of the UT Ex Students Association, University of Texas Chancellors Council, The Littlefield Society, TCU Chancellor's Council, TCU Clark Society, Midland College Foundation and St. Luke's United Methodist Church. He also held a private pilot's license. Jerry was known for his kindness, integrity, and love for others. Relationships were very important to him. He was also passionate about education and established many college scholarship opportunities for countless individuals both locally and within the state. Jerry enjoyed gardening, watching UT football, and working with his sons and grandchildren at the office and the ranch. Jerry is survived by his loving wife and best friend, Carol, son Greg Pitts, son David Pitts (wife Jeanne) their children Jennifer Kaspar (husband Kyle), Nicholas (wife Nicole) and Sara, son Steve Pitts (wife Paige) and their children Zach (wife Jessi) and Amber Boothe (husband Cameron). Jerry was preceded in death by a grandson Trevor Pitts.

Carol Ann Piza (B.A. '81) passed peacefully at her home in Round Rock, Texas, on June 14, 2020 after a five year battle with cancer. Carol was born on June 6th, 1954 in San Jose, Costa Rica to Alfredo and Martha Hale Piza. At the age of four, she moved with her mother to Austin, Texas. She attended St. Austin's Catholic School and Holy Cross High School, where she graduated as Valedictorian. Upon receiving her bachelor's degree in geology from The University of Texas at Austin, she then worked for the State of Texas until her retirement in 2015. Just weeks after retiring, Carol was diagnosed with Neuroendocrine (NET) cancer. She was very active at the time and refused to let her diagnosis stop her from doing the things she loved most —taking care of her granddaughters and volunteering with a local feral cat TNR organization. When faced with this rare form of cancer, Carol did everything she could to learn about the disease and be an advocate and supporter for others facing the same diagnosis. She was active and well known in numerous NET support groups and message boards, and made herself available as a resource to other newly diagnosed patients in the area. Carol is preceded in death by her parents, Martha Hale Piza and Alfredo Piza, and former husband Richard Gray. She leaves behind daughter Megan White (Bill) and granddaughters Olivia and Sara; step-daughter Raechel Brundige (Dakota) and granddaughters Alizeah and Calleigh; sister Laura Vargas and brothers Federico Piza Vargas and Alfredo Herradora and their families; and cousins Tom Paradise III, George Paradise and Walter F. Murphy.

Alexander Webb Ritchie (M.A. '69, Ph.D. '75) died of kidney failure on April 6, 2020, two days short of his 76th birthday. Zan—as he was known to all—asked that there be no funeral service or obituary, requests totally in keeping with his life philosophy. To honor his wishes, this announcement of his departure will be brief. Zan was a lifelong educator who held faculty positions in the geology departments of Furman University, University of South Florida, and the College of Charleston in South Carolina. He was married to the love of his life, Kate, for 45 years, until her death in 2014. As a UT graduate student, Zan was one of Bill Muehlberger's extensive Central American crew; he did his dissertation field work in Guatemala, where he had some hairy adventures, including being run out of his first chosen field area by armed banditos. Farewell, Zan, que te vaya bien!

Ted Vernon Salyer (B.S. '56) passed away October 4, 2019 in Tyler after a brief illness. Ted was born in Texon, Texas, in the Plymouth Oil Camp Hospital on June 29, 1929. His birthplace was in the shadow of the famous Santa Rita No. 1 oil well. As a young boy his dad was transferred to Sinton, Texas. He attended Sinton High School and played the saxophone in the band. He graduated in 1948, and then attended Kilgore Junior College, where he met Joyce. He took a break in his schooling to serve the USA in the U.S. Army and was stationed in Japan during part of the Korean War. Upon returning home Ted and Joyce got married and moved to Austin. He attended The University of Texas at Austin and graduated in 1956 with a geology degree. Dowell Oilfield Services hired Ted out of UT and moved them out to Kermit, Texas. During their 9 years there, Gary and Scott was born. The family then moved overseas for 4 years, first to Trinidad, West Indies and Caracas, Venezuela. Dowell Schlumberger brought him back stateside in late 1968 to work in Kilgore. Ted served as an assistant scoutmaster while in Kilgore. The next move was to Tyler in the summer of 1970. He and his partner, Homer Ward, bought a small asphalt company and named it L&L Asphalt. The 'L&L" came about from Ted and Homer's wives' names. Ted did everything at L&L in the early days, and all those nights with drawings laid out across the dining room table paid off. Ted sold L&L in 1983. He was proud of their continued success which continues to this day. In addition to his firm, a big part of their life back then was Green Acres Baptist Church. He enjoyed watching Church League softball. He also loved deer hunts with Scott and summer trips to northern New Mexico with his family. Joyce and Ted moved to Troup in 1983 and he once again worked in the oil field. He developed an award-winning herd of Black Angus, which he absolutely loved. Joyce, not so much! While residing in Troup, they were members of First Baptist Church Troup. Upon his move back to Tyler, Ted joined Green Acres Baptist Church once again. He is preceded in death by his wife of 63 years, Joyce; his father and mother, W.D. and Ava Cox Salyer; and stepmother, Nina Robertson Salyer; and his brother and sister in law, Don and Lorene. Survivors include his sons and daughters in law, Scott and Toni of Carrollton and Gary and Rita of Troup; and grandchildren Trent and Peyton.

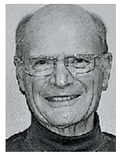
Paul "Zac" Zachary Schorr (B.S. '85) passed away on April 19, 2020. He was born in Corpus Christi, Texas on April 20, 1955. Zac graduated from Travis High School and was honorably discharged from the Navy in 1979 (USS Macdonough). Zac received a bachelor's degree in geology from The University of Texas at Austin. Zac worked in geology, surveying, and as a heavy equipment operator. He was a member of St. Catherine of Siena Catholic Church and had a passion for geology, as well as collecting surveying instruments. He was survived by his brother Pete, and Pete's children Chris, Amanda, and Alex, as well as their families.

Mary Kathreen Sharrai (B.A. '52) passed away on March 2, 2020 in a Plano hospital. Mary was born in Ft. Worth on December 3, 1930 to Charlie Holt Dobbs III and Kathreen (Norwood) Dobbs. Mrs. Sharrai was a member of the First United Methodist Church of Winnsboro, a member of the Standard Club of Winnsboro since 1972 and the Art Society in Mt. Pleasant. She graduated with a BA in geology from The University of Texas at Austin in 1952. Mary was an artist who inspired her granddaughter Janice to become an artist as well. She was preceded in death by her parents; husband Lee Clarence Sharrai in 2007; son Charles Lee Sharrai; daughter Mary Kathreen Rose; brothers Charles H. Dobbs IV and Burt Norwood Dobbs. Mrs. Sharrai is survived by her son-in-law Thomas Wayne Rose; grandchildren Janice Kathreen Rose-Gill and Marc Gregory Rose; grandchildren Caleb Daniel Rose and Karis Kathreen Rose.

James Robert Stephen (B.A. '62) passed away Monday, February 24, 2020. Jim was born on February 10, 1939 in Goldthwaite, Texas to James John Stephen and Roberta Mayo Stephen. He is preceded in death by his parents and is survived by his wife of 53 years, Gloria Stephen and his son, James Todd Stephen. He is also survived by his sister, Joan Little; brother-in-law, Bart Little; and their family. At the age of 5 he moved with his family to Robstown in South Texas, where his father served as the town doctor. Jim attended The University of Texas at Austin for his undergraduate work as a zoology major and the University of Houston, where he completed his graduate studies and earned his license to practice pharmacy. He spent his 50-plus year career working as a pharmacist in the Houston area. Mr. Stephen was an avid reader with a particular interest in World War II history. He was a charter member of the National World War II Museum in New Orleans, LA and the National Museum of the Pacific War in Fredericksburg, Texas, the boyhood home of Fleet Admiral Chester W. Nimitz. He enjoyed outdoor activities, spending time in nature as well as practicing amateur photography. He attended photographic seminars in a variety of places from West Texas to Acadia National Park in Maine. One of his favorite nature adventures was an Earthwatch expedition to Australia, where he helped a team "tag" kangaroos and band birds to track them.

Gene K. Jones Todd (B.S. '48) died December 7, 2019 at her home, after a brief illness. Gene was born April 27, 1927, in San Angelo, Texas, to Ernest Montgomery and Gene Hammond Funkhouser. She moved with her family throughout East and West Texas as oil and gas discoveries were made and fields developed. The family settled in Houston in 1932 where she attended elementary, junior and senior high schools. After moving to Midland in 1943, she graduated from Midland High School in 1944 and attended The University of Texas at Austin where she graduated with a BS degree in geology in 1948. While a student there, she was a member of Zeta Tau Alpha Sorority and the Women's Geological Society, among other organizations. On July 31, 1948, Gene married Joseph Edward. They moved to Midland in October 1948 to open an office for Woodley Petroleum Company where she was employed as a geological assistant. Joseph E. Keyser died April 21, 1975. Gene lived in Midland until the time of her death, raising their five children who continued to be the delight of her life. Gene was active in The Junior League of Midland Inc., Girl Scouts, where she helped lead two Girl Scout troops through junior and senior high school, PTAs throughout the MISD school system and has been a lifelong member of the Episcopal Church and an active member of Al-Anon since 1969. From 1973-1975 she was employed by Ard Drilling Co. and remained active as a secretary working for a number of geologists and land men from 1971 to December 1985, when she retired. On October 1, 1986 Gene married Phillip M. Jones and acquired a new family of three married children and six grandchildren. She also enjoyed gardening, bird-watching, walking, sailing and spending time outdoors at home, at the cabin on Colorado City Lake and on the banks of the Red Deer River in Alberta, Canada. Her greatest delight was family gatherings for holidays, especially July 4th and one on one time with family and friends. After Phil's death in April 2002, she felt privileged to help facilitate the grief recovery program Life After Loss under the auspices of Home Hospice for nine years with her co-facilitator Nancy Meyers. On March 21, 2015 Gene married her longtime friend John B. Todd at a home wedding officiated by Father David Huxley from St. Nicholas Episcopal Church and she acquired a new family—sister-in-law Ellen Todd-Good Artzt and her husband Mike, nephew Alex Good and his son Oz, niece Georgia Redman and sister-in-law Susan Redman. Gene is survived by her own five children and their spouses: Carolyn K. Curtis and Carl, Julie K. Squires and Michael, Edward M. Keyser and Janet, Laura K. Hartsell and Greg, Ann K. Stewart and Dick. Phil's children and their spouses "Dusty" J. Wilson and "Tic", Debbie J. Stucker and Mike, Douglas M. Jones and Nola, who "graciously share their lives with me." Karen McGill Klassen and Gene's grandchildren and their families were an important part of her life. She had 14 grandchildren and 35 great-grandchildren. Jason and Jessica Faulkner, Ryan and Andreanna Stucker, and James and Steven Jones became a part of her family in 1986 when she married Phil Jones. Gene's two brothers and their wives, children and grandchildren had a special place in her heart: Garrett and Carole Funkhouser and Jim and Peggy Funkhouser.

Curry Helmuth Vogelsang (B.S. '60) was born December 28, 1937, in San Antonio, Texas, to the late Helmuth and Emmie Margaret (Curry) Vogelsang. He attended Alamo Heights High School in San Antonio where he played varsity basketball and graduated in 1955. Curry graduated from The University of Texas at Austin in 1960 with a bachelor's degree in geology. He was a member of the Kappa Alpha Order. After working in the oil fields and active duty with the United States Army, Curry attended and graduated from the UT School of Law in May 1964. On December 29, 1962, Curry married the love of his life, Barbara Kay Buchanan. Upon law school graduation, Curry and Barbara moved to Wichita Falls where he began his practice of law. In 1970, Curry and Barbara moved to Sherman where he continued his law practice with various firms until his death. Curry was very active in the community as President of the Chamber of Commerce, served on the Sherman Economic Development Board, and a member of Rotary International. He also enjoyed teaching Criminal Law during two stints at Grayson County College. Curry also considered it an honor and privilege to be the Municipal Court Judge of Sherman for over 41 years from 1974 to 2015. Curry was an elder at Covenant Presbyterian Church and served his Lord and church family in many areas. In his early years, he enjoyed playing tennis and was always found coaching and volunteering in his children's activities. Curry loved a great game of bridge and was known to many as an avid reader. He could often be found watching a Dallas Mavericks game, listening to jazz music, or smoking some barbeque. Curry especially loved golf and shared that passion with a regular group of friends. Curry is survived by his wife of over 56 years, Barbara Kay Buchanan Vogelsang, two sons Curry Vogelsang, Jr. and wife Andrea of Prosper, Chris Vogelsang and wife Lora of McKinney, and one daughter, Katie Vogelsang Stubblefield and husband Sam of Sherman; and nine grandchildren. He was preceded in death by his parents and sister, Nancy Onion.



Charles Osborne Walker (B.S. '59), born April 25, 1936, in St Louis, MO, to William Spurlock Walker and Kathleen Osborne Walker passed away on August 10, 2020.

He is survived by his loving wife, Judith "Judy" Lovejoy Walker. They were married for 62 years. He is survived by his brother Bill Walker; his children, Brad William Walker and wife Linda; daughter, Andrea Michel and husband Jeff; and daughter, Shannon Chambers and husband Curt. He is also survived by his six grandchildren. Charles was preceded in death by his grandson, Gregory Curtis Michel. Charles was a graduate of The University of Texas at Austin and the University of Texas Southwestern Medical School in Dallas (M.D. '63) before completing medical training in Internal Medicine and Gastroenterology. He was a Navy Lieutenant on active duty in Vietnam (1966-1968) and performed postdoctoral research at Southwestern Medical School. He became an Associate Professor of Medicine and was Chief of Gastroenterology at the Dallas Veterans Hospital. Charles went into private practice at Baylor University Medical Center (BUMC) in Dallas. He developed and led the BUMC hyperalimentation service and the BaylorFast bariatric program. He was a faculty member and mentored many BUMC residents and fellows. He founded Texas Digestive Disease Consultants. Charles was a lifelong athlete. In his youth he played baseball and football and ran track. As an adult he pursued mountain climbing, scuba diving and waterskiing. He was an avid tennis player and enjoyed playing piano. Charles loved history and nature. He and Judy raised Brangus cattle in Arkansas for many years. Judy and Charles retired to Arkansas in 1998, where he spent many happy years on his Bear Creek Ranch, entertaining his grandchildren and their assorted dogs with barbecues, boating trips and gator rides. He returned to Texas with Judy and his faithful dog, Kelly, in 2011, to spend his final years closer to family.

Daniel Lee Ward (B.A. '49, M.A. '50) was born in Goose Creek, Texas. He is survived by Grace, his wife of 74 years; daughter, Carol (Jerry Tompkins); son, Stephen (Michelle Ward); seven grandchildren, and 14 great grandchildren. Dan is preceded in death by his oldest son, Daniel Lee, Jr. Dan was an ensign in the U.S. Navy where he flew hell divers in WWII. He graduated with a master's degree in geology from The University of Texas at Austin where he played first chair trumpet in the band. He was a petroleum geologist for Texaco in Midland, Texas and later became an independent geologist. He worked for the Atomic Energy Commission in Grand Junction where he then retired. Dan enjoyed spending time with his family, fishing, hunting and playing golf.

Joseph "Joe" Orby Wheeler (M.A. '56) passed peacefully March 11, 2020. He was born June 17, 1925 in a labor camp tent in a jungle outside Barrancaber-meja, Colombia. Joe was the second of three sons born Katherine Riggs Wheeler of Perris, Texas, and Orby Clinton "Jimmy" Wheeler of Gainesville, Texas. At the time of his birth Joe's father was a pioneering petroleum geologist whose work in Colombia led to the discovery of the La Circa Oil Field. Joe began life with his parents and older brother, James Clinton Wheeler, in a palm thatched hut situated on a river bank of the La Circa-Infantas oil field. His family moved to Toronto Canada when he was four and he remained there until graduating college. He earned a BA in biology from the University of Toronto, a master's degree in biology from Duke University and a master's degree in petroleum geology from The University of Texas at Austin. He spent his career as a petroleum geologist working at Exxon, Atlantic Richfield Co. and Bechtel in exploration and production. Joe met and married Elizabeth "Karlene" Evans Wheeler in Beaumont, Texas, in 1962 while working for Exxon. They raised their three children James Clinton, Thomas Joseph, and Carolyn Eliza-beth Wheeler in Houston. He was a loving, dedicated husband and father. Joe was a modest man with a very dry sense of humor and was known for "zingers" that seem to come out of nowhere. He loved birdwatching, hunting, fishing, gardening, playing the stock market and was an avid reader. He also enjoyed a "sniff" of good bourbon and scotch. Joe was most at peace with his binoculars around his neck identifying birds and taking note of all plants, animals, rocks, and geological formations around him and sharing that with his children. Joe is preceded in death by his wife of 46 years Elizabeth "Karlene" Evans Wheeler, parents Kate Wheeler and O. C. Wheeler, brother James Clinton Wheeler, brother Charles Bowen Wheeler and granddaughter Hannah Renee Wheeler. He is survived by sons James Clinton Wheeler, Thomas Joseph Wheeler, daughter Carolyn Elizabeth Wheeler and granddaughter Caroline Rose Kcenich.

Spouses & Friends

Byron Fred Dyer, Jr. spouse of Connie Dyer, B.A. '58) passed away on April 18, 2020, as a result of complications from both Alzheimer's and colon cancer. Byron attended Baylor University until he was called to serve in the United States Army during the Korean War. Upon his return, Byron enrolled in Lamar University where he received a bachelor's degree in geology in 1957. After graduation, Byron found his love for the oil business and the world of banking. Unlike many, Byron was also able to fulfill a dream of every geologist: in 1957, he was credited with the discovery of a new mineral that was eventually named 'Chambersite'. Byron was preceded in death by his parents, Byron Fred Dyer and Hallie Epperson Dyer; his daughter, Stephanie Leigh Dyer (1965-1974) and his son, Jeffrey Lane Dyer (1960-2019). He is survived by his wife of 60 years, Constance Mayes Dyer; his daughter, Kelly Elaine Gabrisch (Mark) and his son, John Steven Dyer (Christina Gill Dyer). He is also survived by eight grandchildren.

Jo Ellen Larkin Finley (spouse of Judge D. Finley, M.A. '54) passed away on Thursday, April 16, 2020.

Betty L. Gaines (spouse of the late Robert Gaines, B.S. '49, M.A. '51) passed away peacefully in her home in Midland on October 4, 2019.

Nancy Summers Locklin (spouse of the late Allen Locklin, B.A. '54), died on November 6, 2019. Nancy studied at The University of Texas at Austin, where she met the love of her life, Allen C. Locklin. They married in 1955, and God blessed them with a son and daughter. Her marriage to Allen was one for the storybooks, and they were married for an amazing 64 years. Nancy and Allen were avid travelers, visiting all 50 states as well as many countries around the world. Nancy will be greatly missed by her son, Chris Locklin (Lisa), and daughter, Lee Ann Loggins (Les). She was adored by her 10 grandchildren. She cherished her 12 great grandchildren; they brought her great joy.

Jacqueline L. Martin (spouse of the late James L. Martin, B.A. '56) passed away on March 29, 2020. Jackie is preceded in death by her husband of 59 years, James Lee Martin, and her parents, Cathryn and Henry Windes. She is survived by her daughter, Karen; her granddaughter, Melissa; her sisters, JoElla and Deborah.

Marian Maxwell (spouse of the late John C. Maxwell, professor of geosciences) died January 5, 2020. In 1939 she met and married John C. Maxwell. Marian devoted herself to her family and her husband's career, extending hospitality to graduate students and faculty alike. In 1969, a very appealing job offer was made by The University of Texas at Austin, and the couple moved to Austin. John Maxwell died in 2006. Marian and John had two daughters, Judith Margaret and Marilyn Jane. Judy died of Leukemia in 1977. Marian is survived by her daughter, Marilyn.

Carole Miller (spouse of Wayne Miller, M.A. '57) peacefully passed away on March 10, 2020. Carole was born on December 8, 1936 to Edna and George Hill in Mullin, Texas. Carole graduated from Goldthwaite High School. She attended The University of Texas at Austin where she met Wayne, the love of her life. They married on June 8, 1957 then moved directly to Midland, Texas, where her three children were born and raised. Carole was always involved in the many activities her three children were participating in at the time, including Cub Scouts, baseball and softball. She also was involved in the Geologist/Geophysicist Wives Association. Carole is survived by her husband of 63 years Wayne David Miller; son, Craig David Miller and wife, Angel; son, Mark Weldon Miller; daughter, Sharon Elaine Miller; three grandchildren;and three great grandchildren.

Faculty & Researchers

Stephen Craig Ruppel passed away peacefully at his home in Austin on October 21, 2019. He was born in Wabash, Indiana on January 22, 1946 to Harold and Norma Ruppel. Stephen completed his doctoral degree in geology at the University of Tennessee, Knoxville in 1978.

Stephen moved to Montreal, Canada in the fall of 1978, where he met his wife of nearly 40 years, Gera. He and Gera moved to Austin in 1981. As a Senior Research Scientist at The University of Texas at Austin Bureau of Economic Geology, he led research into Paleozoic and Mesozoic mudrock systems, carbonate reservoir characterization, and carbonate sedimentology and geochemistry. He was the editor of the book "Anatomy of a Paleozoic Basin: The Permian Basin, USA" and the author of numerous geological papers.

Stephen enjoyed golfing, cycling, and reading about history. A loving husband, he enjoyed traveling with his wife to Europe, Asia, South America, and New Zealand. A proud and devoted father, he was very actively involved in his sons' lives, taking them on Boy Scout camping trips, to ice hockey games, coaching soccer games, and attending all major events in their lives. He also regularly devoted his time to home renovations and projects, including recently building a catio for the beloved family cat.

He is survived by his wife Gera, his son Erik and fiancée Josie, his son Mark and partner Esther, and cat Holly. Condolences and thanks are also given to his friends, neighbors, and colleagues who were so important to him and supportive of his family after his passing. He will be sorely missed.

Robert H. Tatham, born in California on December 10, 1943, was a beloved husband, father, and grandfather. He attended California University at Northridge, University of Houston, and

Columbia University where he earned a Ph.D. in seismology. He did petroleum exploration research for Texaco before retiring to The University of Texas at Austin where he was a chaired professor in geophysics. His wife, Henna, of 49 years, worked as a pharmacist. They enjoyed travel, family, and community life. Bob was active in synagogue life at Congregation Tiferet Israel, served as a board member and treasurer for the UT Hillel Board, and was instrumental in the creation of the Austin Eruv. His children and grandchildren, daughter Sarah with husband David and children Yehudit, Yael, Yoav and Yakira, daughter Rachel and husband David and children Yonatan and Akiva, and son Benjamin with wife Olive and children Abigail, Miriam, and Isaac, will miss him greatly. Bob will be remembered as a husband, dad, and zayde who was kind, generous, and loving. He will be tremendously missed.

Bill White, longtime Bureau of Economic Geology researcher, has passed away. Bill played a huge role in building the bureau's coastal reputation from the 1970's through the 2000's, particularly in wetlands distribution and change over time, all while being notably modest and unassuming.

"I recall Bill with great fondness from my early years as bureau director," said Scott W. Tinker. "He was a calm and thoughtful presence, and I always enjoyed our conversations."

Colleague and bureau Senior Research Scientist Jeff Paine remembers, "Bill was the principal author of all of the bureau's Submerged Lands atlases and a really wonderful, kind, generous and soft-spoken person."

Bill was with the bureau for over 30 years. During his long and productive career, he was best known for his investigations of the status and trends of wetlands in major bay-estuary-lagoon systems, studies of submerged coastal lands of Texas in which benthic sediments were mapped and characterized, studies of faulting and subsidence and their impacts on marshes, and investigations of fluvial-deltaic systems in which wetland sedimentation rates were measured and correlated with rates of relative sea level rise.

This memorial was originally published on Sept.17, 2020, on the Bureau of Economic Geology website.

Staff

Dennis Trombatore, husband, friend, colleague, philosopher, artist, and lover of life, died peacefully July 18th, 2020 after a long illness. Dennis Trombatore was born on Aug. 26, 1952 in Killeen, Texas, to Marianne Trombatore and Sam Trombatore, who were stationed at Ft. Hood. He grew up in Baton Rouge, LA, where he attended St. Aloysius School and soon-to-be-renamed Lee High, graduating in 1970. He went to LSU, graduating with a bachelor's degree in philosophy in 1975 and an MLS in 1977. He lived in New Orleans and worked at Loyola Library from 1977 to 1980. In 1980 he married Kathryn Dinstuhl; they divorced in 1994. He moved to Athens, Georgia, in 1980 to work in the Science Library of the University of Georgia. In 1985 he accepted the position of Head of the Walter Geology Library at The University of Texas at Austin, where he was honored to receive several staff excellence awards through the years. He made Austin his happy home and worked tirelessly for his second family in the Jackson School of Geosciences until his death on July 18, 2020 from complications of recurrent prostate cancer. In 2004, after a long courtship that began with love at first sight, he married Shiela. Shiela was his beacon in a lonely world and his only regret was to leave her so soon. He is loved and survived by his mother Marianne, his wife Shiela & her family, and friends too numerous to name. Throughout his life, Dennis had a great love for geology and for handcrafts, particularly pottery, which he discovered in college. He was never happier than when in the studio or on a field trip. He belonged to the Austin Geological Society, the Geoscience Information Society, and the National Council of Educators in the Ceramic Arts for many years. Dennis was extraordinarily generous and a polymath in the truest sense. He was a stalwart contributor to the Austin Empty Bowl Project (well over two thousand of his bowls are in use around the city), and a life-long supporter of arts education and higher education.

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ALUMNI NEWS UPDATE SUBMISSION FORM

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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Title

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Print Preferred Email Address in Alumni News?
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❍ No

Class Notes for the 2021 Newsletter

Attach a separate sheet or use the online form at **www.jsg.utexas.edu/alumni** for longer entries.

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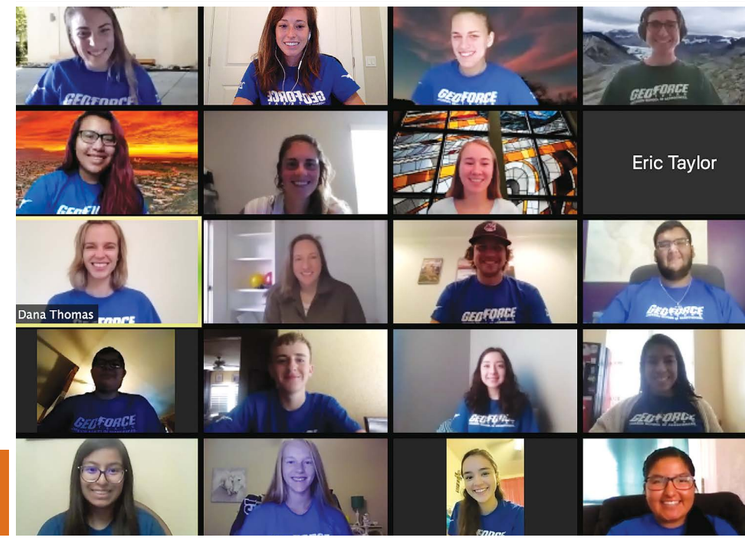

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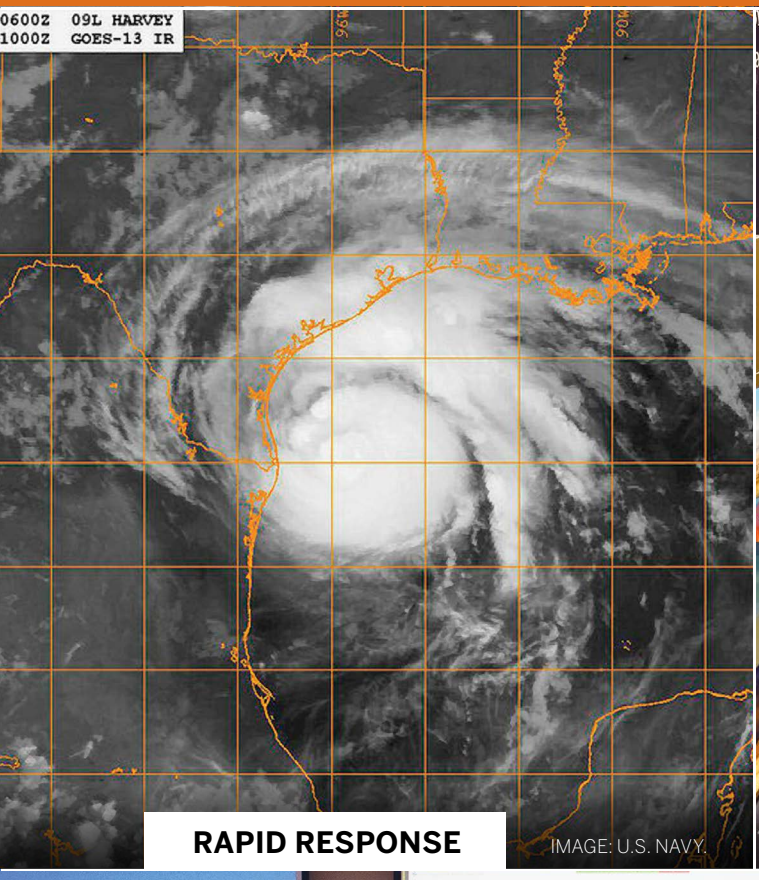

RAPID RESPONSE

IMAGE: U.S. NAVY.

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