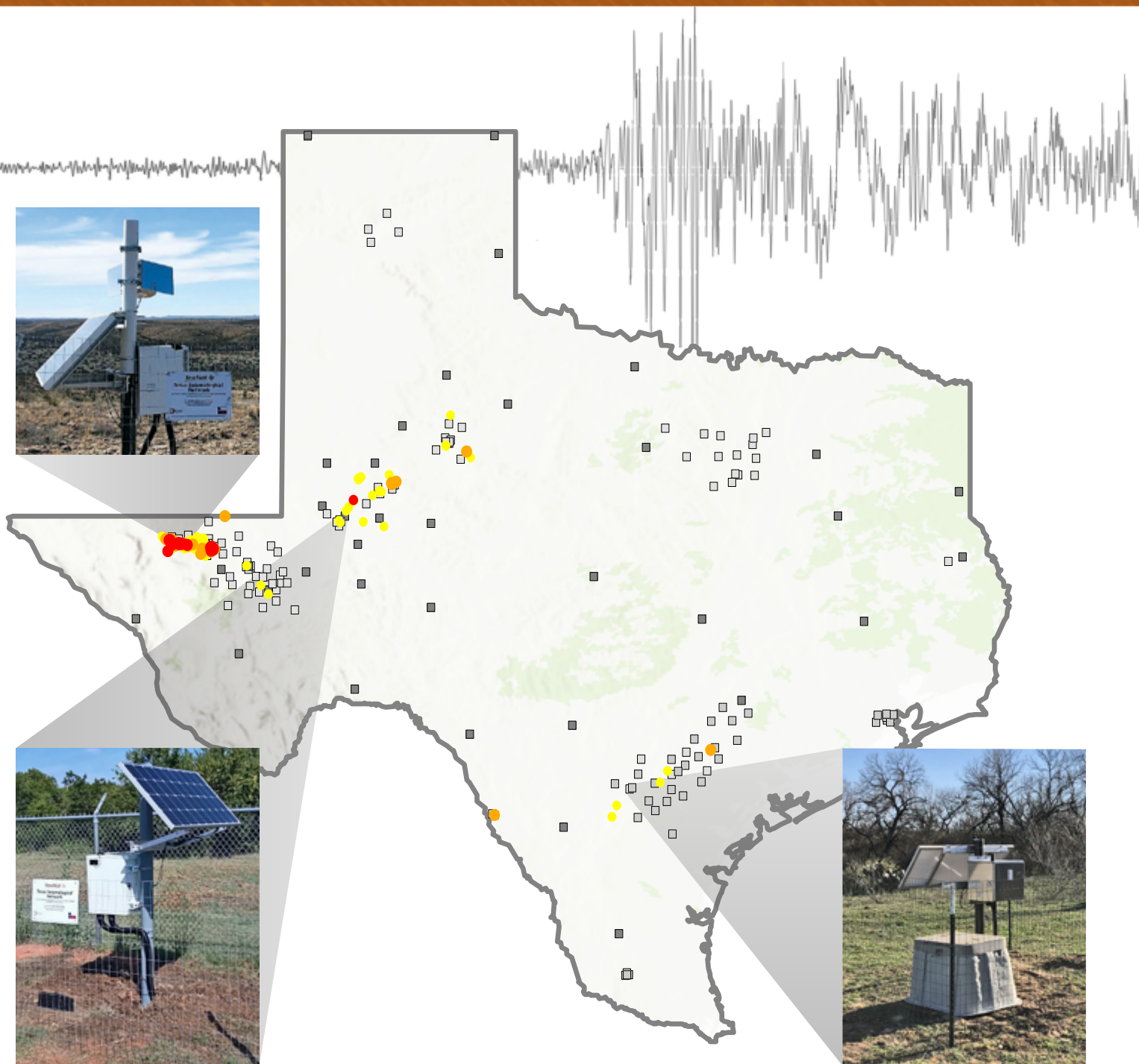


# 2022 Annual Report



Bureau of Economic Geology  
Scott W. Tinker, Director

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2022 Texas earthquake data analyzed by TexNet, the State's authoritative seismological network.

**Red dots:** Magnitude 4.0 to Magnitude 5.5 earthquakes.

**Orange dots:** Magnitude 3.5 to Magnitude 4.0 earthquakes.

**Yellow dots:** Magnitude 3.0 to Magnitude 3.5 earthquakes.

**Black squares:** Permanent seismometer stations.

**Gray squares:** Portable seismometer stations.

**Photos:** Seismometer stations from throughout Texas.

# Message from the Director



Scott W. Tinker

I recently encountered a thought from author Raven Leilani who said, "Imagine living a life so carefully that there are no signs you lived at all."

It almost runs counter to the modern way of life in which, for better and worse, there are plenty of signs that we have lived. Positive signs in art, literature, science, music, and beyond. And negative signs such as environmental impact, human aggression, and the like.

At the Bureau, we intentionally conduct research to optimize resource extraction and use and improve economic health and well-being for all global citizens

while at the same time decrease and minimize environmental impacts caused by necessary human use of earth resources.

To be sure, it is a fine line to walk, but it is important that we are multidimensional in our approach and look at resource systems from start to end. Life cycle assessment is not easy. It involves recognizing, quantifying, modeling, and assessing trade-offs. It involves shades of gray. Most people prefer black and white binary approaches, which are easier to deal with.

But the landscapes across which the Bureau works, both physical and human, are constantly evolving. They are not binary. In this dynamic framework, we seek research impact of the kind that helps all humans to thrive while at the same time minimize the signs that we have lived at all.

## Keep up with the latest from the Bureau



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# Evolving Landscapes, Impactful Research

The world is an ever-changing place, and the last few years have held major challenges while at the same time have presented broad new research opportunities for the Bureau of Economic Geology. The landscapes that met the Bureau evolved in 2022 as it saw increased promotion of non-fossil-fuel energy options and accelerated adoption of emission reduction strategies. The Russian invasion of Ukraine disrupted global energy markets and supply chains. Here at home, inflation and other economic issues exacerbated staffing shortages and the ability to attract and retain key talent. These and other disparate factors influenced the direction of Bureau goals and activities.

The mission of the Bureau of Economic Geology is to serve society by conducting objective, impactful, and integrated geoscience research on Earth resources, energy, the environment, and economics. The organization's research enterprise adapted to evolving landscapes to meet new challenges head-on.

Is a hydrogen economy on the horizon? The GeoH<sub>2</sub> consortium focuses on geological hydrogen storage, related techno-economics, and novel concepts such as in situ generation of hydrogen. Can we utilize the natural heat energy that underlies so much of the Earth's surface? The new HotRock consortium explores tapping geothermal energy as a power source. Is carbon capture and underground storage a viable solution to reducing CO<sub>2</sub> emissions? The Gulf Coast Carbon Center is at the forefront of the science to store CO<sub>2</sub> in rock formations under Texas' coastal waters.

Other Bureau research efforts are equally innovative. The Texas Soil Observation Network uses satellites to measure soil moisture, contributing insights toward drought reduction strategies. The Comparing Electricity Options consortium takes a cradle-to-grave approach to realistically account for the economic and environmental costs of electricity generation methods. The TexNet statewide seismic monitoring network and the Center for Injection and Seismicity Research work to mitigate impacts from Texas' recent earthquake activity. The Economic Mineral Resources Program explores for new supplies of critical minerals and rare earth elements to meet the nation's increasing requirement for these strategic ores.

This 2022 Annual Report recounts the wide range of efforts that Bureau of Economic Geology researchers, students, and staff undertook in the pursuit of producing impactful research. We hope you enjoy it!



# ● ● News and Events ● ●

## TexNet-CISR Hosts Annual Review



TexNet-CISR program researchers **Alexandros Savvaidis** and **Peter Hennings** presenting at the Annual Review.

The Texas Earthquake Monitoring and Research Program (TexNet) and the Center for Injection and Seismicity Research (CISR) hosted a joint two-day Annual Review for approximately 100 stakeholders and partners at the Bureau of Economic Geology in Austin. Those in attendance included members of the Governor's TexNet Technical Advisory Committee, petroleum industry sponsors (including the CISR Science Advisory Committee), technical staff from the Railroad Commission of Texas, and collaborating scientists from Southern Methodist University, the University of Houston, and Southwest Research Institute.

During the review, over 30 technical presentations were made including an overview of recent seismicity in Texas, analyses of the earthquakes, geological and geophysical analyses of the subsurface conditions stemming from petroleum industry activities that are

linked to earthquakes, new understandings of the hazard posed by the increase in seismicity, newly developed tools to help understand and mitigate the earthquake hazard, and other topics. A focus of the presentations was on advances in data and monitoring for an improved understanding of recent earthquakes in the Permian Basin region of West Texas and southeastern New Mexico. The meeting concluded with a discussion of the most significant goals ahead for TexNet and CISR.

## FRAC Embarks on Next Quarter Century

The Fracture Research and Application Consortium (FRAC) held its 25th Annual Research Meeting late last year, marking 25 years of progress in learning how to characterize and predict fractures and their effects on engineering operations. The meeting included 17 live presentations, 7 prerecorded talks, a virtual fieldtrip to the Canadian Foothills with field trip leader **Esti Ukar**, and a software demonstration workshop. FRAC Principal Investigators **Stephen Laubach** and Jon Olson gave an overview of FRAC's cutting-edge work on fracture modeling. The challenge of building predictive models to understand and optimize energy extraction is widely recognized. The goal is to break down the complexity of fracture system behavior and rebuild it into a modeling approach that reliably and verifiably predicts attributes that govern fluid flow and rock strength. FRAC research is investigating fully 3D interactions between individual fractures governed by friction laws and communicating via chemistry and fluid flow, using simulations, laboratory experiments, and natural examples to unravel these interactions. To make reliable predictions, it is necessary to include interactions between fractures at all scales and to couple mechanical and diagenetic processes. BT Lee, a Ph.D. student in

the program, presented new work on a computationally efficient physics-based modeling approach that couples mechanics and diagenesis and showed that for the first time a numerical code reproduced the types of fracture size distributions observed in nature. Collaborator John N. Hooker illustrated a numerical approach that is being incorporated into the predictive model that accounts for the effects of variable cement accumulation on fracture spatial arrangement. Geoscience Ph.D. students are using novel approaches to reconstruct natural



Geothermal outcrop analogs, upstate New York. FRAC students and staff along with Cornell students and professors describe a premier fracture exposure. FRAC research established principles for selecting appropriate subsurface analogs. Photo: Ann Laubach.



fracture pattern evolution to compare with model results. This basic research direction promises to revolutionize fracture pattern prediction over the next few years.

Practical engineering solutions and technology transfer are also central to the FRAC mission. The annual meeting workshop, led by Jiacheng Wang and Jon Olson, was an interactive demonstration of in-house hydraulic-fracture modeling software that uses innovative methods to take geology into account. FRAC members had the opportunity to install the software and were able to run models in real time. Fracture research remains highly relevant to the development of naturally fractured geothermal and petroleum reservoirs and to improved efficiency in unconventional reservoirs that require stimulation. Work on fundamental natural fracture processes and on hydraulic-fracture generation will continue. For major initiatives, we leverage industry support with other resources. For example, **Julia Gale** and **Sara Elliott** are describing fractures in core as part of a new DOE-funded hydraulic-fracture test site project, where the interest is on refracturing. In a cross-disciplinary initiative, Esti Ukar is leading a project aiming to capture fracture information from drilling data. A big challenge is sorting useful information on fractures from other signals in the data. Colleagues with drilling expertise in the UT Department of Petroleum Engineering are working on this aspect. New fracture characterization protocols and spatial arrangement software are under development as inputs for discrete fracture models. Collaboration with FRAC sponsors on case study projects has also been strong, allowing us to take in-depth looks at issues from which general principles can be inferred.

Fracture research is going to be key for successful endeavors in energy transition projects; there will be opportunities in both geothermal and carbon sequestration initiatives. FRAC scientists are developing collaborations in several such projects. For example, Stephen Laubach will lead core fracture description work on a Cornell University geothermal research well. Preliminary fieldwork in New York in collaboration with Cornell scientists on a geothermal outcrop analog saw the deployment of FRAC's new drone, and Ph.D. student **Stephanie Forstner's** work in Wyoming is also an exceptional outcrop analog for geothermal sources. The possibility of sequestering carbon dioxide (CO<sub>2</sub>) in unconventional reservoirs will also require fracture knowledge, especially regarding risk associated with CO<sub>2</sub> containment. Julia Gale is building a team to work on this topic, taking advantage of the Bureau's collective knowledge of unconventional reservoir geology and fracture systems. The FRAC group looks forward to the next phase of innovation in research and is actively seeking new data sets, collaborative projects, and sponsors to add to the portfolio.



Xavier Janson (left) and Charles Kerans in a screen grab from a virtual field trip video in Dog Canyon, New Mexico.

## RCRL Outcrop-Based Research Enters the Next Phase

The carbonate Reservoir Characterization Research Laboratory (RCRL) is a program built on the principal that outcrop exposures are a fundamental link to the explanation and description of 3D reservoir environments in the subsurface. The recent pandemic has revealed two challenges of the outcrop—characterization of the valuable complexities shown in the exposures and how to get more geoscientists to see and appreciate these in their everyday work.

Techniques that bring the outcrop to the geoscience desktop have been at the forefront of RCRL research. Since its inception in 1987, the RCRL group has led the field in applying tools such as high-resolution panoramic photography, ground-based and airborne lidar, differential GPS mapping, and drone-based photogrammetry to better characterize carbonate reservoir analogs. The detailed outcrop characterization work is used to illuminate complex correlations between cores, wireline logs, and seismic data. Amassing a large catalog of characterized digital outcrops, RCRL is now embarking on the next phase of bringing the outcrop to the desktop—virtual reality. Today's geoscientists are faced with growing demands on their time or restrictions on their travel (e.g., COVID issues). Furthermore, not every geoscientist is capable of reaching some of the more challenging locations that are required to see firsthand the perfect spot for understanding their reservoir.

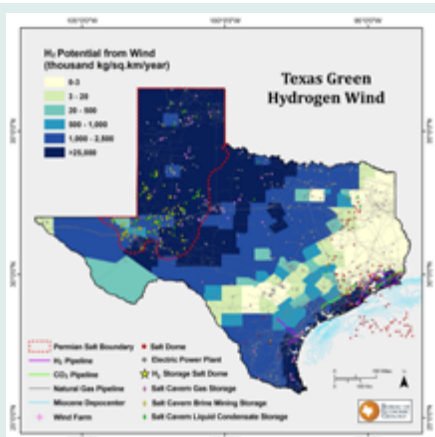
There are two approaches being used by RCRL to put the geology on the desktop. The first involves creating digital outcrop models in virtual reality (VR) environments. In VR, users traverse through digital outcrops in a similar way that modern video games allow first-person streaming of fictional worlds. However, the VR world developed by RCRL is a high-quality replication of the outcrop. As a user

virtually walks through the outcrop, the user is able to see the important interpretations placed on the outcrop by an experienced field geologist and can see tagged relevant references such as an interpreted photograph or can see a subsurface wireline log correlation that is similar to the scale of the exposure being visualized. A second approach of bringing the outcrop to a wider audience is the documentation of classic and new field trips by video filming each stop as it is presented by a field trip leader. As many geoscientists are aware, nothing beats having an expert point out the value and insight an outcrop provides to their understanding. RCRL's field trip to the Sacramento Mountains was captured on video in two ways. The first was the standard filming of the leader presenting their work (video at <https://youtu.be/da-lTlMcwPM>) while the second was a 360-degree camera simultaneously capturing the outcrop and the field trip leader's description (video at <https://youtu.be/gYdTQQYd2-A> - be sure to use your mouse to rotate the video!). Outcrops and field trips will always be a fundamental part of geology, but new techniques provide people with valuable insight from the view of world experts. The RCRL team continues to find innovative ways to bring this experience to people that need it the most. On that note, preparations are underway for a field trip to the Keeler and Darwin basins in the Death Valley, California area. Stay tuned! You may soon be able enjoy this experience from the comfort of your desk chair!

organizations participating. We hosted over 70 individual participants during the course of our two-day, online meeting." GeoH2 presented ongoing and planned research on three themes: geological storage, in situ generation and novel concepts, and techno-economics and value chain analysis. Sixteen researchers shared various aspects of their work within the themes of the new consortium. Mark Shuster related, "The broad participation in this first meeting reflects the strong and growing interest in hydrogen, and, in particular, the need to better understand geological storage of hydrogen as part of future hydrogen value chains." Shuster continued, "This includes improving our understanding of how hydrogen behaves in different reservoirs, identifying potential risks and mitigations, and ways to optimize value chains. The intent with hydrogen is to be able to inject and then produce back hydrogen as a fuel for a spectrum of end usages."

## STARR Program Researchers Present at East Texas Geological Society Expo

Research Scientist and State of Texas Advanced Resource Recovery (STARR) program Principal Investigator **Lorena Moscardelli** and Program Director **Ian Duncan** delivered keynote presentations during the 2022 East Texas Geological Society Prospect and Tech Expo in Tyler, Texas. Moscardelli provided attendees with an overview of STARR's ongoing oil and gas projects in partnership with several Texas operators. The overview included snapshots of technical work by the STARR team on the Frio Formation, the Barnett unconventional play, and



Texas green hydrogen wind at GeoH2 meeting.

## New Hydrogen Research Consortium Holds Kick-Off Meeting

GeoH2, a new research consortium at the Bureau of Economic Geology, held a very successful

inaugural meeting with sponsoring companies and organizations. The mission of GeoH2 is to conduct geoscience, reservoir engineering, and economic research to facilitate and advance the development of a hydrogen economy at scale.

GeoH2 Principal Investigator and Bureau Deputy Director **Mark Shuster** reported, "As a brand new consortium, we were delighted to have 10 international companies and



STARR program researchers (Peter Flaig and Kelly Hattori), presenting at the East Texas Geological Society Expo.



the Tannehill sandstone. In addition, STARR's approach to regional studies was demonstrated using examples from the Lower Cretaceous Pettet Formation in East Texas and the Cisco Group in the Eastern Shelf. Moscardelli also discussed new STARR initiatives, including ongoing work on salt formations for the purpose of energy storage, including hydrogen storage, as well as new initiatives in geothermal energy and critical minerals.

Duncan then delivered a talk online on the topic of "Fracking and Refracking," discussing how refracking wells not optimally fracked is rarely profitable. As a result, refracking in most unconventional plays occurs in only a very small percentage of wells, generally less than 1 percent. STARR Research Associate Bo Ren was also in attendance, and both he and Lorena Moscardelli had great interactions with a wide range of operators from the Tyler area. The event was hosted in the beautiful Tyler Rose Garden, and STARR researchers were very grateful for the hospitality of Ernest LaFlure of the East Texas Geological Society and Rich Adams of Carr Resources who had at the time visited the STARR team in Austin to discuss an ongoing project on the Strawn Group in Scurry County.

## TORA Program Unveils Interactive Portal to U.S. Shale Gas and Tight Oil Play Studies

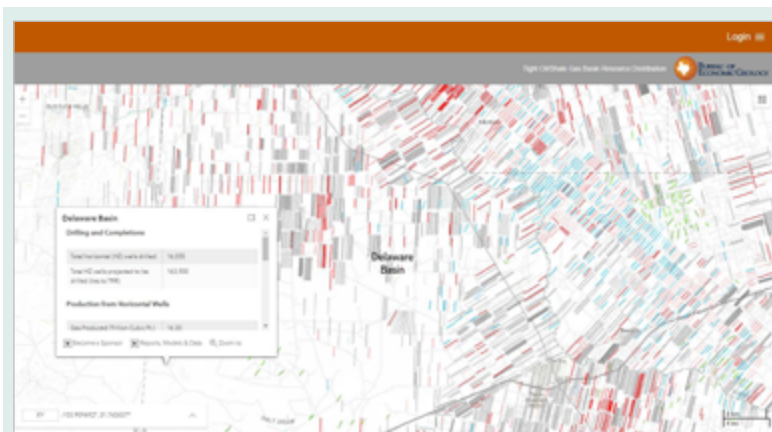
The Bureau of Economic Geology's TORA (Tight Oil Resource Assessment) consortium is pleased to announce the launch of a new, interactive online portal into its comprehensive studies and maps of U.S. shale gas and tight oil plays. TORA's play-wide but granular mapping highlights areas of highest productivity, in-place resources, and technically recoverable resources (TRR) based on a robust workflow, which characterizes the subsurface and incorporates economic analysis, including profitability-driven future activities. A limited version of the portal will be available to the public with TORA member organizations having access to the full content of the basin and play content. "We're very excited to have released this new portal to our sponsors and now to release some general interest content into the public domain," remarked Bureau Director **Scott Tinker**. "The war in Ukraine is exacerbating the energy crisis in Europe, which is less resilient due to policies forcing production towards expensive and unreliable sources. It's more important than ever for the United States to have a science- and economics-based understanding of its resource endowment and the development potential of its major tight oil and shale gas plays."

Designed by Bureau web developer **Aaron Averett**, the main goal of the new sponsor-restricted version of the

portal is to create an intuitive, user-friendly, and interactive space allowing sponsor management and staff to directly access their TORA reports, presentations, shape files, and models. The version of the portal accessible by the public contains three main features: 1) a single click inside a play outline brings up a callout box with summary information, 2) an interactive feature showing the evolution of horizontal drilling in 10 different U.S. basins using a wide choice of base maps, and 3) a link to a short slide set containing visual volumetric comparisons of oil and gas resources, TRR, and production to date from horizontal wells for each play. "These detailed maps of the major U.S. tight oil and shale gas plays will evolve continually as important new research adds to our understanding of them," remarked TORA's former Principal Investigator,

**Emery Goodman**. "The new sponsor-restricted portal is a major benefit for TORA partners, allowing them to quickly access key features of TORA research. The new public version will provide folks a window into the great potential these plays have for U.S. oil and gas production over time."

TORA began in 2016 as a new research consortium at the Bureau, and consortium partners include corporations and other energy-related organizations. Its research builds on prior groundbreaking Bureau studies of U.S. shale plays funded by the Sloan Foundation and the U.S. Department of Energy. While TORA's current focus is on the Permian Basin, its research continues to revisit other key tight oil and shale gas plays in the United States. TORA's mission is to provide its stakeholders with reliable, unbiased, and up-to-date projections, models, and insights at the basin scale for the major U.S. unconventional plays. TORA conducts innovative, integrated research of in-place resource and recoverable volumes, play and well economics, and production forecasts with their environmental implications. You can access the public version of the portal at <https://maps.beg.utexas.edu/toraportal/>.



TORA interactive online portal image of the U.S. shale gas and tight oil plays.



**Peter Hennings** addressing the participants at a seismicity workshop in West Texas.

## Bureau of Economic Geology Team Conducts Seismicity Workshop in West Texas

The rates of anthropogenic earthquakes in Texas have increased significantly in the last few years, especially in the Permian Basin region. Understanding induced seismicity does not require deep technical skills, but it does require the thorough synthesis of geophysical, geological, and reservoir engineering data.

The Bureau of Economic Geology's **Alexandros Savvaidis**, Manager and Principal Investigator of the TexNet Earthquake Monitoring Network, **Peter Hennings**, Principal Investigator of the Center for Injection and Seismicity Research (CISR), and **Jean-Philippe Nicot**, Senior Research Scientist, Hydrogeology and Reservoir Engineering, conducted a one-day workshop in Midland, Texas. Under the auspices of the West Texas Geological Society, the researchers introduced concepts in induced seismicity research and provided the background skills required to understand its cause and be conversant in how it is monitored and analyzed.

About 80 participants heard presentations providing timely information on seismologic monitoring, earthquake analysis, earthquake hazard and risk, mechanics of fault rupture, fault characterization, fault rupture sensitivity analysis, pore pressure analysis, performance of causal analysis, evolution of induced seismicity hazard, and mitigation steps. The workshop was tremendously well received, and other associations have inquired about the Bureau conducting similar workshops in the near future.

## The Bureau's TORA Consortium Conducts Technical Conference

The talented multidisciplinary team from the Tight Oil Resource Assessment research consortium (TORA) held its spring meeting and technical conference at the Bureau of Economic Geology in Austin, Texas. There were 70 representatives from sponsoring organizations participating either in person or virtually, and the TORA team presented a wide range of information about its latest production research in the Permian Basin and the Haynesville region. There were 19 integrated presentations conducted during the two-day event covering geoscience, reservoir engineering, economics and business, data analytics, and machine learning, with a particular focus on new insights, interpretations, and workflows.

Although it was announced that he would be entering retirement soon, respected longtime TORA Principle Investigator **Emery Goodman** kicked off the meeting with an opening report summarizing current research. Goodman discussed the net results of the Bureau's over 10 years of investigating tight oil and shale gas plays and shared an overview of in-place resources, technically recoverable resources (TRR), and production to date for the 10 major United States shale plays. He reported that despite significant horizontal drilling in the Permian Basin even developed plays are relatively immature and just a fraction of their TRR has been produced to date. Later that afternoon, Bureau Chief Economist **Ning Lin** discussed a new methodology to translate TORA's production outlook into electricity load forecasts incorporating Permian Basin upstream and midstream future electricity requirements. After completion of the first day's presentations, participants and TORA researchers enjoyed a reception and networking event featuring live music.

While the focus of the event's presentations was predominantly the Permian Basin Wolfcamp and Spraberry tight oil and gas plays, the conference included a half-day review and update on the Haynesville region, including an upward-revised assessment of natural gas TRR for the Haynesville and Bossier plays.



**Emery Goodman** addressing participants at a TORA member meeting.





Stephen Laubach presented the keynote address at the Geological Society of America's Penrose Conference.

## Steve Laubach Addresses Penrose Conference

Bureau of Economic Geology Senior Research Scientist **Stephen Laubach** presented the keynote address at the Geological Society of America's Penrose Conference that focused on progressive brittle failure in rocks. Laubach's well-received keynote was on the "Role of Chemistry in Fracture Pattern Development" and was related to his paper, "The Role of Chemistry in Fracture Pattern Development and Opportunities to Advance Interpretations of Geological Materials" published in *Reviews of Geophysics*.

The interesting conference hosted a unique audience of roughly 80 participants. The progressive brittle failure that the audience was interested in has to do with modern, contemporary fracture and how it pertains to hazards (i.e., rockfall, etc.) and landscape evolution. This field of geomorphology and civil engineering is undergoing a period of rapid development influenced by ideas of reaction-enhanced fracture propagation. "There seem to be many opportunities here for new directions (and funding) for the Bureau inasmuch as there are considerable societally important issues at play that our research, expertise, and ideas can contribute to," commented Laubach. He continued, "There also may be grounds for collaboration across the Jackson School as some of our researchers are in this community."

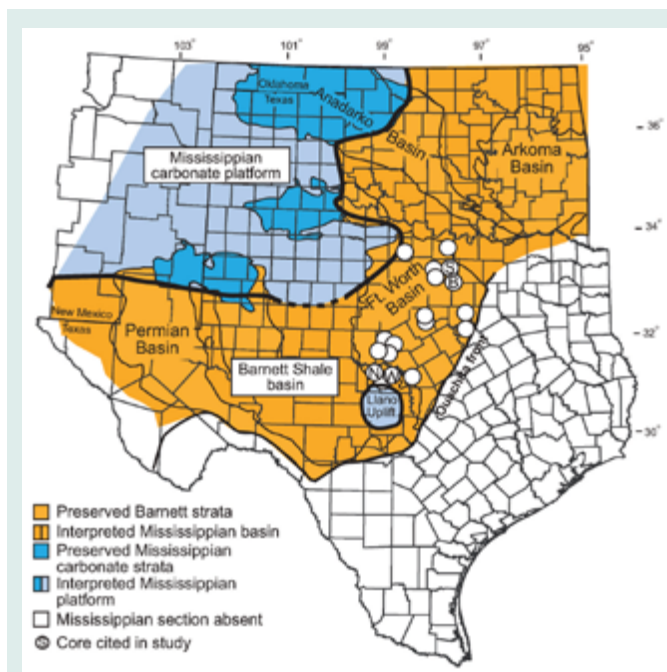
## Another Measure of the Bureau's Success

There are many ways to measure success. In today's social media world, the number of followers you have or the number of times your video was viewed lets you know what others think. Television programs

rely on ratings, and movies track box office returns. In academia, the number of times one's published research paper is cited by other researchers is a powerful measure of success, and, with its researchers' citations, the Bureau of Economic Geology certainly measures up.

One of the Bureau's primary objectives is to earn and maintain an international reputation as a leading scientific research institution working at the confluence of energy and other natural resources, the environment, and economics. In order to accomplish this objective, the organization places a very high value on the main product of its research, the published papers of its researchers. Publishing is not only encouraged but is a key component in evaluating a researcher's performance. Over the past four years, the Bureau's researchers have published approximately 125 peer-reviewed papers annually.

These papers share new scientific insights and innovative findings with the world, and other researchers take note by citing them in their own research. The number of times a particular paper is cited is a strong indication of how groundbreaking or important it may have been to the scientific community. The number of citations a published paper receives can be measured using online tools, and Bureau authors are frequently cited by their peers.



Paleogeographic map of the southern midcontinent region during the middle Mississippian Period showing Barnett Shale sample locations. Four cores are cited in this study: Mitchell Energy Corp. T.P. Sims #2 (S), Texas United Blakely #1 (B), Houston Oil & Minerals Walker #D-1-1 (W), and Houston Oil & Minerals Neal #A-1-1 (N). Also shown are 14 other wells from which samples were analyzed. Modified from Ruppel and Loucks (2008).

A 2009 paper in the *Journal of Sedimentary Research* titled "Morphology, genesis, and distribution of nanometer-scale pores in siliceous mudstones of the Mississippian Barnett Shale," by **Robert Loucks, Robert Reed**, the late Steve Ruppel, and Bureau collaborator Dan Jarvie, has just passed the 3,000-citation mark, demonstrating tremendous academic recognition. This marks Loucks' third paper with more than 1,000 citations. Among other current Bureau researchers who have had papers with 1,000 or more citations are **Julia Gale, Charles Kerans, Jerry Lucia, Kitty Milliken, Bridget Scanlon, and Tongwei Zhang**. Many other researchers have had papers published that have hundreds of citations. The substantial number of citations that Bureau of Economic Geology researchers' papers have earned over the years is a strong indication of the great international reputation that the organization and its renowned researchers maintain.

## GeoH<sub>2</sub> Research Consortium Hosts Annual Fall Meeting

The Bureau of Economic Geology's GeoH<sub>2</sub> research consortium conducted a very successful Annual Fall Meeting. Thirty sponsor representatives from 11 sponsoring organizations participated both in person,

at the Bureau, and virtually, and heard intriguing presentations from 18 researchers involved in the study of hydrogen as an energy resource.

All of the presentations fell under one of five major themes: Porous Media, Salt Characterization & Heterogeneities, Techno-Economics & Value Chain Analyses, Risk Analysis & Monitoring, and Novel Concepts & New Directions.

GeoH<sub>2</sub> undertakes research relevant to the understanding of geological storage of hydrogen and related development of value chain pathways, and

novel concepts, ranging from the fundamentals of gas dispersion in-reservoir, to in situ generation of hydrogen, to occurrences of native hydrogen. "There is a very strong interest in developing hydrogen as part of a reduced carbon economy," explained **Mark Shuster**, Bureau Deputy Director and Coprincipal Investigator of the consortium. "GeoH<sub>2</sub> provides insight to the sponsors on how geological storage fits into the envisioned hydrogen



**Mark Shuster** addressing over 70 individual participants at the GeoH<sub>2</sub> Annual Fall Meeting.

## Bureau Research Symposium Brings Researchers Together

For the first time in two years, the Bureau of Economic Geology conducted its annual in-person Bureau Research Symposium. By all accounts, it was a great success. Bureau researchers presented 12 nano talks and lined the facility's multipurpose room with 21 informative posters. The event was very well attended, and those present seemed to be delighted with being able to meet together and exchange ideas about their work for the first time in quite a while. The Symposium achieved its goal of building collaboration among scientists who are sometimes siloed in their respective labs and offices.

Led by Bureau Information Geologist **Linda Ruiz McCall**, the event team included **Jessica Rowling, Evan O'Donnell, Roanne Draker, Kim LaValley, Kenneth Edwards, Francine Mastrangelo, Jason Suarez, Carson Werner, and Michael Wang**.

Participants were encouraged to vote for their favorite posters and nano talks. The Best Poster Award went to **Bissett Young, Hassan Dashtian, Tyson McKinney, and Michael Young** for their poster, "Updating the Texas Soil Observation Network (TxSON)." Two presenting teams tied for Best Nano Talk: **Justin Thompson and Michael Young** for "When Wells Fail: a Hydro-Economic Approach for Quantifying Well Performance Thresholds and Groundwater Yields" and **Toti Larson and Evan Sivil** for "High-Resolution Facies Stacking and Reservoir Attributes across Wolfcamp A-B and Third Bone Spring Sand, Delaware Basin: a Machine Learning Approach to Integrate Core and Wireline Measurements." Bureau Director **Scott Tinker** praised the participants: "Congratulations to the 'voters' choice' winners of best poster and talk," he said. "Every talk that I heard and poster that I stopped by was terrific! Keep up the great work."



Bureau researchers **Sara Elliott** and **Qiqi Wang** discuss their poster with Bureau Director **Scott Tinker**.



value chains and what issues need to be addressed to increase the technical readiness of hydrogen for future deployment. Similarly, CO<sub>2</sub> provides informed views on novel concepts for alternative supplies of hydrogen as well as fundamentals of gas behavior in reservoirs."

## TORA Program Hosts Informative Annual Meeting

The Bureau of Economic Geology's Tight Oil Resource Assessment (TORA) research consortium held a very successful 2022 Annual Meeting at the Bureau. The meeting included a broad spectrum of presentations about the current status of its research as well as an overview of current research plans and future possibilities for study.

TORA's vision is to be recognized as the premier entity researching U.S. unconventional resource plays and their production capabilities, developing a basin-wide and granular-scale understanding of key factors controlling current and future developments. The research consortium's mission is to provide its stakeholders with reliable and up-to-date estimates, projections, models, fundamental understanding, and insights at the basin scale for the major U.S. unconventional plays by conducting innovative, integrated research of in-place resource and recoverable volumes, play and well economics, and production forecasts along with their environmental implications.

Fifty-two sponsor representatives joined the meeting, both in person and virtually, and heard informative presentations by 14 speakers on a wide range of topics ranging from the role of natural gas in European and global markets to the produced water challenge in the Permian Basin. Sponsor recommendations for future areas of heightened study included: advancing TORA's productivity analyses, developing a geomechanical facies classification, and producing basin-to-basin comparisons (particularly Midland vs. Delaware).



Tim McMahon, Principal Investigator addressing participants at the TORA member meeting.

New TORA Project Manager **Tim McMahon** noted after the meeting that the research team will be brainstorming ways to potentially increase in-person participation at the next meeting as it is felt that the resulting personal interaction promotes a high level of discussion and sponsor-to-sponsor exchange of ideas.

## MSRL Conducts Wide-Ranging Core Workshop

The Mudrocks Systems Research Laboratory (MSRL) consortium hosted an in-person core workshop and short course at the Bureau's Core Research Facility. The event was attended by 36 geologists, petrophysicists, and reservoir engineers from 11 companies.

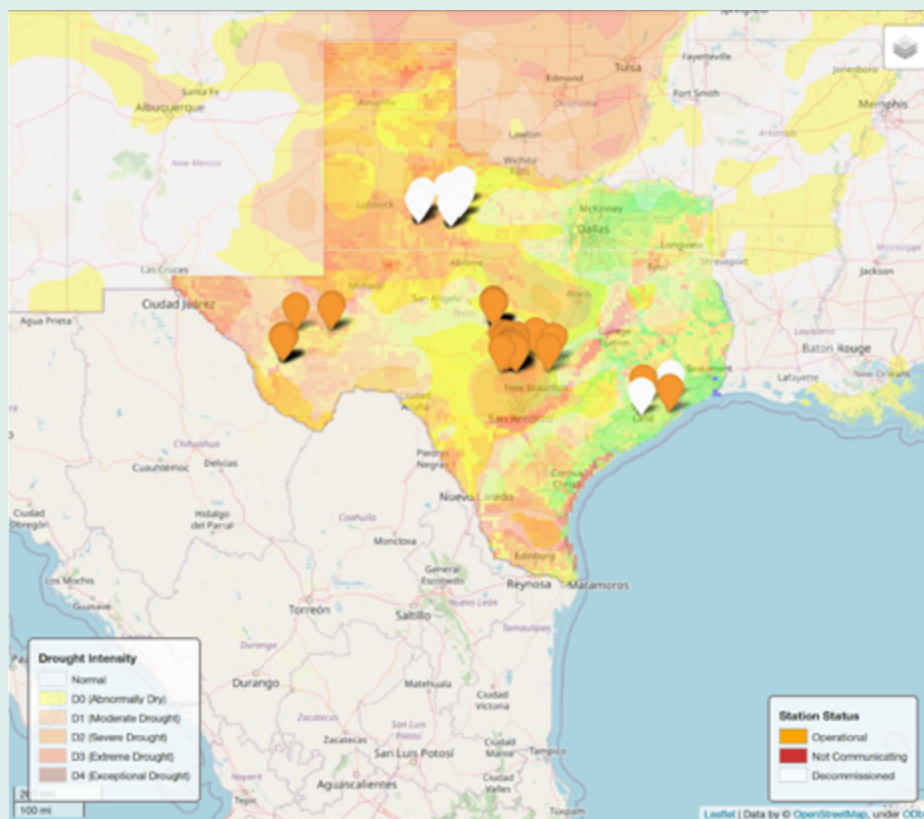
The core workshop featured nearly 4,000 ft of core from the Wolfcamp, Bone Spring, Spraberry, Austin Chalk, and Eagle Ford formations, highlighting MSRL's commitment to improving reservoir characterization through integrated core characterization and wireline log studies. Short course topics covered measurement and modeling approaches used to evaluate pore systems and permeability, oil and water saturations, liquid hydrocarbon geochemistry, quantitative micropetrography, diagenesis, and machine learning tools used to upscale and integrate core measurements to basin-scale models.



Toti Larson and Bill Ambrose discussing core logs at the MSRL core workshop.



Lucy Ko discussing core logs at the MSRL core workshop.



The TxSON interactive map allows users to get a big-picture view of drought in Texas and on-the-ground soil moisture measurements with one application. Credit: TxSON.

Senior Research Scientist **Kitty Milliken** provided an invited lunch lecture titled “Mudrock Heterogeneity, Rock Properties, and Reservoir Quality—Two Decades of Advances.” All told, it was a great event that fostered science discussions across disciplines and provided new research directions for MSRL to pursue in 2023.

## UT Austin Refreshes Texas Drought Tracking Tool

Over the past year, researchers at The University of Texas at Austin have been working to improve the accessibility of soil moisture data collected by a network of monitoring stations known as the Texas Soil Observation Network, or TxSON. The result is a new web application created by the Bureau of Economic Geology. The site includes an interactive map of Texas showing satellite-derived drought information and the latest on-the-ground soil moisture readings from the 58 active TxSON stations ([www.beg.utexas.edu/research/programs/txson/map](http://www.beg.utexas.edu/research/programs/txson/map)).

TxSON has been collecting data since 2015. According to **Bissett Young**, a researcher at the Bureau who helps manage the TxSON network, the new application presents the network’s excellent record of soil moisture

conditions from across the state. “Anywhere there’s a station, you can go,” she said. “You can zoom in and see what’s going on with the soil water data and see what’s going on with drought across the state.” Soil moisture is a key indicator of drought and can drastically affect agriculture and livestock. While rain gauges show how much precipitation fell in a region, soil moisture shows how much water is actually absorbed into the ground and potentially available to plants. Soil moisture also can influence flooding risks and whether rain runs off into parched reservoirs. The TxSON stations provide precise and frequent measurements. Precipitation, soil water content, and soil temperature are recorded every 5 minutes at multiple depths—generally at 5, 10, 50, and 100 centimeters—and transmitted every hour. Some TxSON stations are outfitted to take additional readings. Eight stations collect weather data, such as wind speed and direction, temperature, relative humidity, and solar radiation. Three stations in West Texas measure water quality and flow at natural springs. These readings are also available on the interactive map.

Whether a rancher, researcher, or an interested member of the public, the refreshed TxSON web presence offers a way for anyone to better understand on-the-ground



conditions from multiple perspectives across Texas, said Bureau Director **Scott Tinker**. "TxSON represents an excellent example of how the Bureau, as the State Geological Survey of Texas, is improving the collection and delivery of vital environmental data to stakeholders across the state," he said.

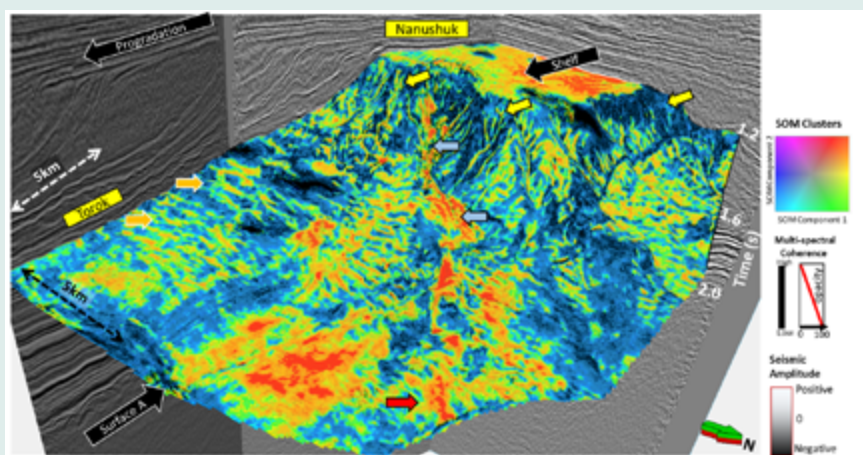
## Machine Learning: A Powerful Tool for Bureau Research

Data is the lifeblood of geoscience research. Bureau of Economic Geology researchers gather reams of data from a myriad of sources. Core, cuttings, outcrops, fluids, gases, satellites, drones, seismometers, sensors, scanners, and an array of equipment all provide huge amounts of data for cataloging and analysis. This was once an incredibly daunting task, but, for several years now, Bureau scientists and engineers have utilized machine learning as an extremely powerful tool to expedite and enhance their research. We set out to find researchers who benefit from machine learning practices and to learn about how it is used here at the Bureau. Here's what we found:

- Senior Research Scientist **Sergey Fomel** reported, "My group (the Texas Consortium for Computational Seismology, or TCCS) pioneered the use of machine learning in analyzing 3D seismic images for automating interpretation tasks traditionally done by human interpreters: picking geological faults, salt bodies, and channels. We also found numerous other applications of machine learning in analyzing seismic data and solving tasks such as data reconstruction, noise attenuation, modeling seismic wave propagation, improving the resolution of seismic images, and the accuracy of full-waveform inversion."
- Research Scientist **Toti Larson** explained, "The Mudrock Systems Research Laboratory (MSRL) has developed a machine learning workflow called CorePy that improves visualization and data integration of high dimensionality, spatially complex, and multimodal core-based data sets." "Importantly, this workflow can be deployed using open-hole wireline logs alone, which expands the use of core-based facies classifications 'beyond the core' to the basin scale."
- Senior Research Scientist **Zoltán Sylvester** reported, "Our research group (Quantitative Clastics Laboratory, or QCL) has been using machine learning

techniques to detect individual grains in images of detrital zircons and modern sand samples. We use a Unet-type convolutional neural network to perform semantic segmentation." Sylvester continued, "This workflow has the potential for quickly deriving a large amount of data from any sand sample and to compare and contrast sands of different origins."

- Research Associate **Shuvajit Bhattacharya** shared, "We have used machine learning for automated data filtering, rock type classification, and rock property predictions in an integrated manner that honors geology." He continued, "We have developed a new workflow on multiattribute-based unsupervised machine learning and supervised autoencoder-decoder networks. We integrated our machine learning solutions with rock data and identified the reasons behind bad samples in some locations in the Permian Basin. This allowed us to build more accurate petrophysical models in areas lacking core data." Bhattacharya went on, "We have been able to incorporate a certain amount of geologic and petrophysical concepts and quantitative relationships directly into machine learning modeling or physics-based machine learning. This enables us to predict rock properties in areas with limited and scattered data with high accuracy and consistency at a basin scale." Finally, he stated, "We used unsupervised and semisupervised machine learning to label and map some very complex features on the entire 3D seismic data set, which we then updated at a few locations based on geologic knowledge. This process helped us to quickly interpret large volumes of data and reduce some degree of human bias while preserving important geologic information in the interpretation."



A 3D view of the Nanushuk-Torok succession with multispectral coherence attribute corendered with unsupervised self-organizing map-based (SOM) facies clusters along surface A. The orange arrows: the sediment wave; yellow arrows: channel; blue arrows: canyon; red arrow: basin floor fan (from Verma and others, 2022). Data courtesy of the State of Alaska, Department of Natural Resources, Division of Oil & Gas, AS 43.55 Exploration Tax Credit Project.

# • • Honors • •



## Bureau of Economic Geology Receives Award for Environmental Stewardship

The Bureau of Economic Geology's TexNet seismic monitoring program and its Center for Injection and Seismicity Research were recognized for their extensive work toward earthquake mitigation in the Permian Basin with the presentation of the Bruno Hanson Environmental Excellence Award. The award was presented to the Bureau and its corecipient, the Railroad Commission of Texas, by Midland College at its annual Permian Basin Environmental Regulatory Seminar hosted by the Permian Basin Petroleum Association.

The Bruno Hanson Environmental Excellence Award is presented annually to recognize an organization or individual's exceptional achievement in environmental stewardship. Any business, professional organization, government, State or city agency, educational institution, or individual that has an environmental project, procedure, or program in the Permian Basin that exceeds industry standards can be recognized for its commitment to environmental excellence. The recipients must be able to demonstrate significant progress in either impact to the environment or resource conservation.

## Bureau Celebrates 2022 Staff Service Awards



Jeffrey  
Paine

Bureau of Economic Geology leaders, researchers, and staff convened to celebrate and honor Bureau team members who have served The University of Texas at Austin for 10 years or more and to recognize one staff member who contributed exceptionally to the Bureau's mission of energy, environmental, and economics research over the past year. After Bureau Director **Scott W. Tinker** delivered his opening remarks, he presented staff members with awards to recognize service anniversaries beginning with 10 years and reaching 40 years of contribution to UT Austin's success. Senior Research Scientist **Jeffrey Paine** received the 40-year award. **Melissa Coffman** earned the Outstanding Staff Award for her dedicated work as the leader of the Bureau's human resources department over the past year and the preceding few difficult years.



Melissa  
Coffman

## Oliver Duffy Wins the Robert Mitchum Award



Oliver  
Duffy

Bureau researcher **Oliver Duffy** and his coauthors have been awarded the 2022 Robert Mitchum Award for the paper "Principles of shortening in salt basins containing isolated minibasins," which appeared in Volume 33 of the journal *Basin Research* published in February of 2021.

The annual Robert Mitchum Award is presented by the European Association of Geoscientists and Engineers (EAGE) to the author of the best paper published in *Basin Research* during the preceding calendar year. The winning paper must meet high scientific standards and should represent a significant contribution to one or more of the disciplines represented by the journal. Duffy's informative paper explains that in settings with isolated minibasins, and a high salt volume, shortening induces salt flow, and that the flow of salt contributes to the translation, tilt, and rotation of minibasins during shortening.



## Shuvajit Bhattacharya Wins SEG Karcher Award



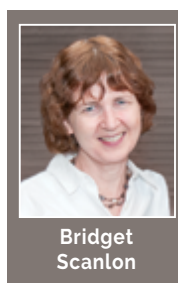
Bureau of Economic Geology researcher **Shuvajit Bhattacharya** received the 2022 J. Clarence Karcher Award from the Society of Exploration Geophysicists (SEG) at the SEG-AAPG International Meeting for Applied Geoscience & Energy (IMAGE). The Society gives the Karcher Award to recognize "significant contributions to the science and technology of exploration geophysics by a young geophysicist of outstanding abilities."

The SEG Honors and Awards Committee and Board of Directors cites Bhattacharya, a member of the Bureau's Tight Oil Resource Assessment research team, as a "rising star in our profession." The SEG citation praises Bhattacharya for authoring the most-downloaded *Interpretation* research article in 2020 and for his contributions to geologically oriented machine learning in general, integration of 3D seismic attributes with deep learning in particular, and carbon sequestration. The citation also notes his "attention to scientific rigor." In addition to his research achievements, SEG honors Bhattacharya for his noteworthy service as cochair of technical sessions at SEG Annual Meetings, as special issue editor for multiple issues of *Interpretation*, and as deputy associate editor of *Interpretation*.

## Bureau Rainmakers Recognized

The Bureau of Economic Geology depends on the entrepreneurship of its researchers to attract funding that supports their work, and the most productive of these "rainmakers" were recognized at a dinner held in their honor. Hosted by Director **Scott W. Tinker**, the Rainmakers' Dinner brought the Bureau community together to celebrate these resourceful individuals and the lucrative grants that they secured during the past year.

Despite having to raise money in a year of economic uncertainty, Bureau researchers relied on ingenuity and a host of new research concepts to convince a diverse list of government, industry, and foundation funders to make grants. Those rainmakers recognized, listed alphabetically, included **Mohsen Ahmadian, Alex Bump, David Chapman, Jacob Covault, Oliver Duffy, Sergey Fomel, Emery Goodman, Peter Hennings, Xavier Janson, Jay Kipper, Stephen Laubach, Ning Lin, Timothy "Tip" Meckel, Lorena Moscardelli, Jean-Philippe Nicot, Jeffrey Paine, Alexandros Savvaidis, Kutalmis Saylam, Mark Shuster, Alex Sun, Zoltán Sylvester, Ken Wisian, and Michael Young.**



Bureau Visiting Committee member Elliott Pew and his family sponsor the Pew Family Bureau of Economic Geology Rainmaker of the Year Award, a cash award supporting the individual's work. This year's Rainmaker of the Year Award recipient, recognized for her exceptional success in attracting funding this year, was **Bridget Scanlon.**



**Bureau Rainmakers** (Top left to lower right) **Scott W. Tinker, Mohsen Ahmadian, Alex Bump, David Chapman, Jacob Covault, Oliver Duffy, Sergey Fomel, Emery Goodman, Peter Hennings, Xavier Janson, Jay Kipper, Stephen Laubach, Ning Lin, Timothy "Tip" Meckel, Lorena Moscardelli, Jean-Philippe Nicot, Jeffrey Paine, Alexandros Savvaidis, Kutalmis Saylam, Mark Shuster, Alex Sun, Zoltán Sylvester, Ken Wisian, and Michael Young.**



**Bridget Scanlon** was selected to be the lecturer for the 2022 William Bowie Lecture by the American Geophysical Union.



Bureau Director **Scott W. Tinker** received both the Ben H. Parker Memorial Distinguished Service Medal from the American Institute of Professional Geologists and the President's Award from Energy GeoAlliance.



**Stephen Laubach** was selected as an Outstanding Reviewer by the American Geophysical Union.



**Charles Kerans** received the Robert R. Berg Outstanding Research Award from the American Association of Petroleum Geologists.

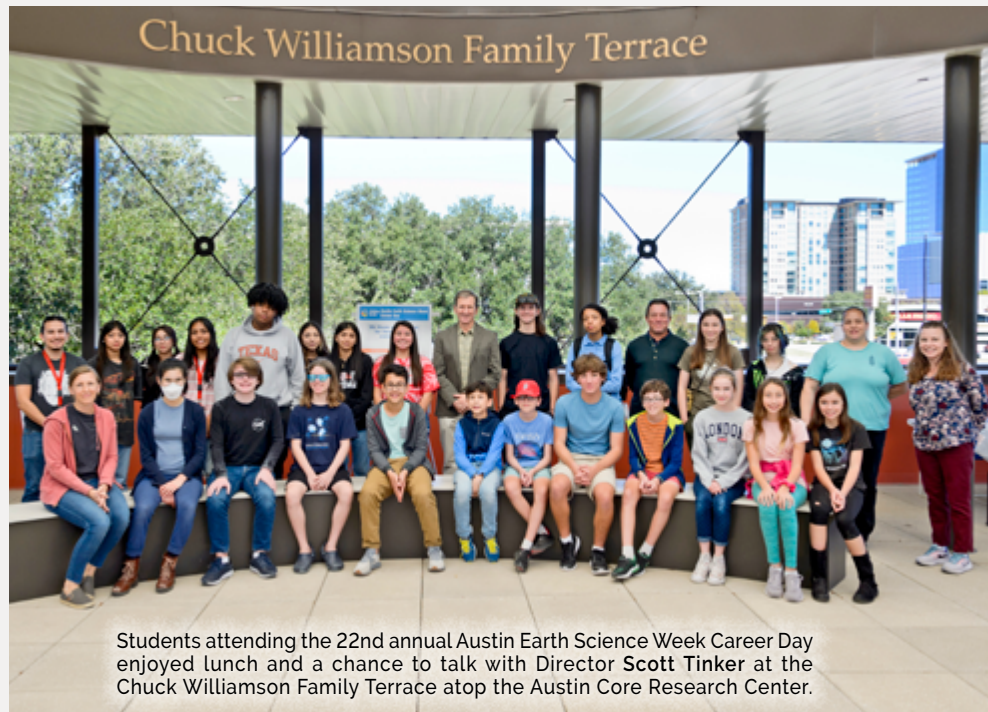


**Sergey Fomel** was selected to receive Honorary Membership by the Society of Exploration Geophysicists.

# ● ● Outreach ● ●

## Austin Earth Science Week Career Day

The 22nd annual Austin Earth Science Week Career Day was held on October 21. After a two-year hiatus of in-person events due to the COVID-19 pandemic, middle and high school students came to the Bureau's facilities to meet face-to-face with scientists and learn about the wide range of geoscience careers. The experiences of the day included presentations, demonstrations, hands-on activities, and tours of the Austin Core Research Center, the Stoneburner Family Rock Garden, and the Mineral, Rock, and Fossil Gallery. Students visited an inorganic chemistry laboratory, core warehouse and viewing room, and a soil monitoring station. Special thanks to Chuck and Cathy Williamson and David and Nancy Pustka for their financial support of this program.



Students attending the 22nd annual Austin Earth Science Week Career Day enjoyed lunch and a chance to talk with Director **Scott Tinker** at the Chuck Williamson Family Terrace atop the Austin Core Research Center.



Earth Science Week students learn about topographic maps by interacting with an augmented reality sandbox.



Gulf Coast Carbon Center staff teach students about carbon capture with hands-on activities and demonstrations.

## Texas GeoSigns and Geoheritage

In July of 2022, the **Texas GeoSign Project** received a generous gift from Mr. Daniel Barnes of Trinity, Texas, which established the Stephen E. Clabaugh Geoheritage Fund, an endowment providing ongoing support. The mission of the Texas GeoSign Project is to establish a network of geologic information signs to engage and educate people when they visit parks, highway rest areas, and other public locations. For information on the initiative, or to contribute to the Fund, please contact **Linda Ruiz McCall**.







## AIPG GEODAYZ Conference

In August of 2022, the Bureau hosted the Texas chapter of the American Institute of Professional Geologists (AIPG) GEODAYZ conference. Approximately 40 attendees listened to presentations about the latest research in geothermal, hydrogen, produced water, and geophysical studies. In the afternoon, attendees took part in a core workshop and tour of the Austin Core Research Center. **Mark Shuster, Ken Wisian, Bridget Scanlon, Jeffrey Paine, Lorena Moscardelli, Toti Larson, Kelly Hattori, Linda Ruiz McCall, and Nathan Ivicic** all gave presentations to the group to provide them with insight into the broad array of geoscience research at the Bureau.

Linda Ruiz McCall and AIPG attendees in the Stoneburner Family Rock Garden.

## Texas High School Coastal Monitoring Program

The **Texas High School Coastal Monitoring Program**, led by **Tiffany Caudle**, continues work with students to monitor the beach and dune system on Bolivar Peninsula, Galveston Island, Follet's Island, Matagorda Peninsula, Mustang Island, northern Padre Island, and South Padre Island. The collected data has been used to investigate beach, dune, and vegetation-line recovery following tropical cyclones; monitor the effects of nourishment projects, beach maintenance practices, and jetty construction; and verify shoreline positions for updates of Texas' long-term shoreline change rates.



Texas High School Coastal Monitoring Program students monitoring the beach and dune system.



## EarthDate

**EarthDate** is a public service radio program with a mission to engage listeners in earth science and reconnect them to the wonders of their world. EarthDate tells captivating stories to remind listeners that science can enlighten, educate, and entertain. At the end of 2022, *EarthDate* offered 296 episodes and is reaching audiences through more than 400 radio stations worldwide.



# ● ● Research Consortia ● ●

## Research Partnerships with the Bureau of Economic Geology



Download the consortia brochure: [www.beg.utexas.edu/about/reports-and-information](http://www.beg.utexas.edu/about/reports-and-information).

The Bureau of Economic Geology conducts objective, impactful, and integrated geoscience research on subjects of high interest to a broad spectrum of stakeholders including energy and environmental firms, government agencies, and the scientific community, a great number of which actively participate in its many research consortia. Each consortium is designed to complement partner efforts to research a key exploration, production, environmental, or energy economics question. Participation is on a subscription basis. Member benefits vary, but generally include first-look privileges at research outcomes, access to research teams, invitations to annual review meetings, and individual meetings with researchers for presentation and dialogue.

Members also benefit from interactions with counterparts in fellow member organizations. Each Bureau research consortium has a dedicated team of full-time Bureau researchers. Many of them host talented graduate students, with the teams combining seasoned experts and early career specialists. Experienced and effective senior researchers lead each consortium.

Contact the principal investigator of any program of interest to you. For further information about these research consortia, or about the breadth of your organization's engagement with the Bureau, please contact us at [www.beg.utexas.edu](http://www.beg.utexas.edu) or by phone at 512-471-1534.



## Advanced Energy Consortium



### Mission

Our mission is to illuminate the subsurface reservoir using novel micro- and nanosensing technology developed collaboratively with Advanced Energy Consortium (AEC) members and the global community.

### Research Thrusts

Over the past decade, the AEC has played a significant role in enabling nanotechnology solutions for the oil and gas industry. In collaboration with our member companies and researchers, the consortium has evolved from fundamental research at individual university labs into a set of integrated, multicomponent, and multi-institutional applied research programs, transforming the technology of subsurface monitoring and creating exciting field demonstrations to validate our technology in 2022. The AEC's reach has extended far beyond simply oil or gas applications and now encompasses a broader spectrum of alternative energy and environmental applications.

### Research Challenges

In the decade since its inception, the AEC has progressed nanotechnology from fundamental to applied research and is now targeting commercial applications such as precise reservoir imaging of hydraulic-fracture networks using electromagnetic-contrast agents; microsensor-data logging in wellbores, pipelines, and other infrastructure; and targeted payload deliveries in a host of environments.

### Membership

Now is truly an excellent time to be a part of the AEC family. AEC research revenues are increasing as we attract new members. Our level of innovation remains unsurpassed, and we are a recognized leader in nanotechnology research, as demonstrated by our numerous filed patents and papers and our team's prestigious 2019 Best Paper Award from the *Journal of Environmental & Engineering Geophysics*. We invite companies who are ready to transform the future of the energy industry to talk with us about empowering people and protecting the environment using advanced technology.

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## Applied Geodynamics Laboratory



### Mission

Pure and applied research in salt tectonics has been a strong component of the Bureau's research program since the late 1970's. Applied Geodynamics Laboratory (AGL) research comprises a mix of physical and mathematical modeling, seismic- and field-based mapping, and structural, stratigraphic analysis of some of the world's most spectacular salt basins. In addition, starting in 2019, the AGL added a new research theme investigating mobile shales. Here we use our existing expertise in diapirism and seismic interpretation, combined with physical and mathematical modeling, to understand the origin, evolution, and seismic imaging of mobile-shale structures.

### Research Thrusts

Concepts and terminology pioneered by the AGL over the past quarter century have profoundly influenced salt tectonics and are now widely disseminated throughout the oil industry. The AGL strives to effectively communicate these results via a variety of media, including *Salt Tectonics: Principles and Practice*, the leading textbook on the subject in the world.

### Research Challenges

The primary goals of the AGL are to develop a conceptual framework for the full range of salt and mobile-shale tectonics; to analyze connections among physical models, mathematical models, seismic data sets, and field examples from all over the world; and to disseminate complex technical information to a constantly shifting spectrum of industrial and academic supporters. Areas of focus include mobile-shale mechanics; mobile-shale piercement mechanisms; salt weld; salt canopy; reactive, falling, and squeezed diapirs; shape of passive diapirs and sheets; fault families (with the University of Colorado); extrusive salt sheets (with BP and ExxonMobil); extensional turtle and mock turtle structures; mechanics of salt-sheet advance; the origins of minibasins; intrusive salt plumes; and salt sutures.

### Membership

The 21 supporting companies of the AGL include a wide range of industry partners from around the world.

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## Comparing Electricity Options



### Mission

The mission of the Comparing Electricity Options (CEO) research consortium is to conduct a three-phase, data-driven study that highlights trade-offs among society's goals of mitigating climate change, improving local environments, and providing reliable and affordable energy that can sustain a healthy economy for future populations. The goals of the CEO consortium are to create tools that support energy sector decision makers with better economic and environmental assessments to manage environmental, social, and governance risks across global supply chains; highlight where innovation can mitigate impacts; and inform policies that encourage innovation.

### Research Thrusts

We are using several methodologies and are developing interactive tools to allow wider audiences to quickly compare alternative scenarios. In Phase 1, we conduct a life-cycle (LCA) assessment of power plants for 18 impacts covering greenhouse gas and local emissions, land and water use, and biodiversity and ecosystem services. The LCA system boundaries encompass extraction of natural resources, manufacturing of generation equipment, power plant operations, and end of life. In Phase 2, we investigate electric power grids instead of individual power plants, and aggregate environmental impacts and costs associated with transitioning generation mixes over time, including new transmission and distribution infrastructure. In Phase 3, we use results from Phases 1 and 2 to develop a new cost estimate for electricity that includes environmental and system costs.

### Research Challenges

There are many materials and technologies with complex global supply chains. Values for numerous inputs vary widely across locations. Publicly available data on global supply chain activities, each with many processes, are often scarce. Hence, we must analyze numerous scenarios for LCAs, power systems, and consumer costs, while continuously pursuing new information, preferably primary data, from supply chain stakeholders.

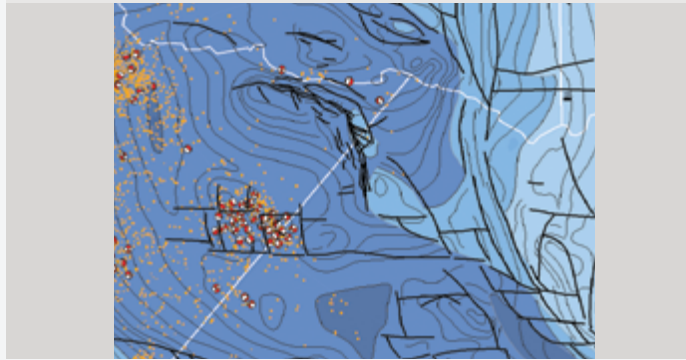
### Membership

CEO is currently funded by six industrial affiliates. Membership is tiered to accommodate all interested partners.

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## Center for Injection and Seismicity Research



### Mission

The Center for Injection and Seismicity Research (CISR) is a multidisciplinary, intercollegiate research consortium. TexNet and CISR are two parts of a whole. CISR significantly extends and deepens the scope of research into induced seismicity and develops an understanding of the processes that influence seismicity, quantifies the evolving hazards, and, therefore, improves standards of practice for mitigation.

### Research Thrusts

CISR conducts fundamental and applied research to better explain seismicity of all causes, its associated hazards, and the implications to subsurface industry activity. CISR relies on research specialists spanning geology, seismology, geomechanics, hydrogeology, reservoir engineering, and data science and collaborates broadly with other institutions within Texas and beyond.

### Research Challenges

In 2022 there were more earthquakes in Texas with presumed human cause than in any year prior. There were also earthquakes with larger releases of energy. This seismicity occurred primarily in basins undergoing unconventional petroleum development. The handling of water produced with oil and gas is quickly becoming a challenge to the sustainability of current practices employed by the petroleum industry. Understanding the interplay between the complex operational drivers of induced seismicity and interdependent subsurface physical processes is a daunting challenge that the Bureau is pursuing head-on.

### Membership

Most of the major energy companies that operate in Texas' unconventional plays and international operators with no assets in Texas are CISR members. Each company has one member who serves on the CISR Advisory Committee. Member companies are encouraged to enter into secondary confidentiality agreements with the CISR research team to contribute proprietary data and information that can guide and advance CISR research. Proprietary data is protected by UT Austin's strong intellectual property controls.

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# Fracture Research and Application Consortium



## Mission

Fracture research at The University of Texas at Austin seeks fundamental understanding of fracture processes with the aim of finding new geological, geophysical, and engineering methods to explain and successfully predict, characterize, and simulate reservoir-scale structures. The research is both fundamental and practical, aiming at improving prediction and diagnosis of fracture attributes in geothermal and hydrocarbon reservoirs and accurately simulating their influence on production. Research is organized around the Fracture Research and Application Consortium (FRAC) and conducted together with scientists from member companies. Students are an important part of our program.

## Research Thrusts

Accurate prediction and characterization of fractures hold great potential for improving production by increasing the success and efficiency of exploration and recovery processes. New analytical methods produce data that can enhance well test and seismic interpretations and can be used in reservoir simulators. We are developing new and more reliable methods to quantify fracture patterns in 3D and to predict hydraulic-fracture propagation in naturally fractured, geothermal, and unconventional reservoirs.

## Research Challenges

Faults and fractures are difficult or impossible to characterize adequately using currently available technology. Fractures have been challenging to sample and model, posing serious obstacles to exploration and development. Our approach is helping to overcome the limitations of current methods.

## Membership

Training in techniques, software, and our workflow is a benefit of membership. Annual meetings cover measurement, interpretation, prediction, and simulation of fractures and mechanical properties in carbonate rocks, mudstones, and sandstones.

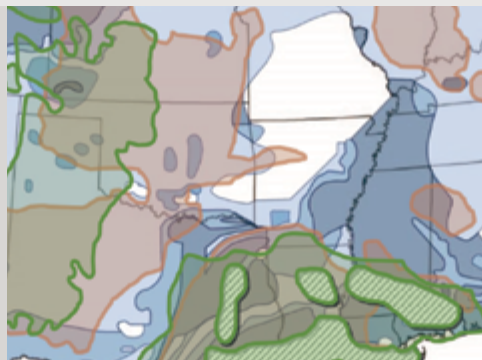
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# GeoH<sub>2</sub>



## Mission

GeoH<sub>2</sub> conducts geoscience and economic research to facilitate and advance the development of a hydrogen economy *at scale*. GeoH<sub>2</sub> connects industry professionals in the energy and power sector with researchers in energy geoscience, subsurface engineering, and energy economics to conduct subsurface hydrogen storage research and technology development, market feasibility analyses, and to explore novel subsurface concepts related to hydrogen.

## Research Thrusts

Research activities include reservoir modeling coupled with laboratory experiments to understand the behavior of hydrogen in geologic reservoirs such as depleted fields, saline aquifers, and salt dissolution caverns. This work informs techno-economic analyses for different reservoir types and fields for a range of anticipated energy markets and regulatory frameworks. Concepts such as in situ generation of hydrogen, controls on natural hydrogen, and dispersion of hydrogen in reservoirs are also investigated.

## Research Challenges

While subsurface hydrogen storage can build on decades of natural gas underground storage, the unique properties of hydrogen require an adaptation of existing storage technology to account for differences in storage capacity, reservoir integrity, and requirements on hydrogen purity. Existing proven storage technology in underground salt caverns requires a reassessment for further upscaling. Predictive economic models of industrial-scale subsurface hydrogen storage face uncertainties in market, regulatory, and technology development.

## Membership

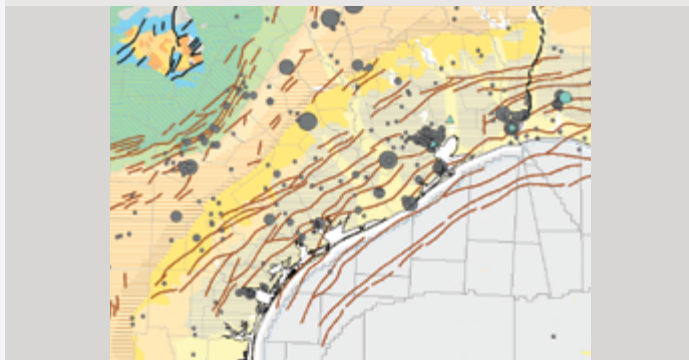
Consortium members will meet twice a year for research and development reviews, with additional project planning and review meetings as needed. Training and sponsor company visits can be arranged in person or virtually.

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## Gulf Coast Carbon Center



### Mission

The Gulf Coast Carbon Center (GCCC) conducts research and training in geologic storage technologies used to reduce emissions of carbon dioxide (CO<sub>2</sub>). CO<sub>2</sub> is captured from either highly concentrated emissions from industrial facilities or low concentrations from the atmosphere. Once captured, CO<sub>2</sub> is injected kilometers below the ground surface into porous rocks for permanent storage, and the CO<sub>2</sub> becomes isolated from the atmosphere.

### Research Thrusts

The GCCC's mission and research into large-volume CO<sub>2</sub> storage achieves the following: (1) improves structural and stratigraphic characterization methods and simulation approaches for identifying suitable storage locations; (2) creates pore- to basin-scale workflows to help projects operate at maximum injection rates and over prolonged periods of time; (3) assesses storage resources in offshore subsea settings in the Gulf of Mexico and globally; (4) develops and tests monitoring approaches to meet regulatory and social license operating demands; (5) monitors long-running CO<sub>2</sub>-enhanced oil recovery projects to help address the intersection of economic and storage value while also assessing life-cycle considerations; and (6) provides information and outreach on carbon capture and storage (CCS) to a variety of stakeholders.

### Research Challenges

CCS deployment is not happening at the rate and scale needed to achieve global emission reduction goals. Many influential stakeholders, from industrial investors, policymakers to journalists, do not have the proper information needed to see the critical role of CCS in order to attain these goals and the viability of CCS.

### Membership

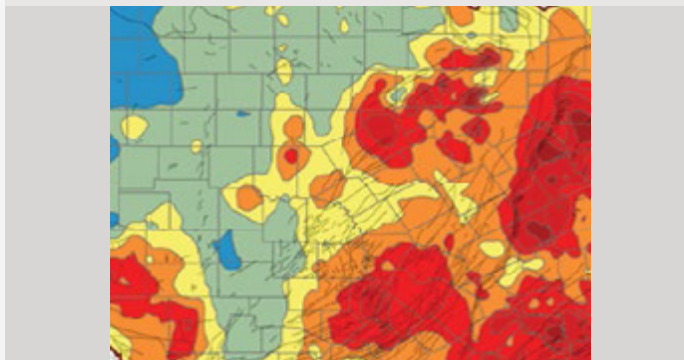
Members meet twice a year, sometimes jointly with other related groups to discuss priority areas of research, and members receive a quarterly newsletter to stay updated with GCCC events and activities.

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## HotRock Geothermal



### Mission

HotRock is an industry-funded research consortium to find and fill the science and technology gaps needed to further develop the geothermal anywhere ecosystem. This will incorporate science, engineering, economics, policy, and entrepreneurship efforts and will be led by the Bureau, an organization with the skills and proven track record to lead a major enterprise such as this.

### Research Thrusts

The HotRock research consortium will address the broadest of research and engineering topics, from deep within the subsurface to the consumer, including subsurface geology and engineering; surface power generation, grids, economics, and policy; and direct heat applications for heating and cooling, agriculture, etc. As these applications have disruptive impact in the race to lower carbon emissions, the scope will be international, exploring how resources and certain technologies that are successful in one region could be scaled up in others.

### Research Challenges

Evident issues that need work include but are not limited to the following: fit-for-purpose geothermal reservoir characterization—best indicators of suitable heat reservoirs—transfer of oil and gas methodology into geothermal; downhole tools and methods for well construction, well monitoring, and production enhancement; modeling heat transfer in fractures and into wellbores; supercritical CO<sub>2</sub>-rock interactions; induced seismicity monitoring and mitigation, higher-temperature materials, sensors, cements, etc.; comparing designs and economics of diverse methods for harvesting heat; techno-economics of converting heat to electricity; low-temperature heating and cooling uses.

### Membership

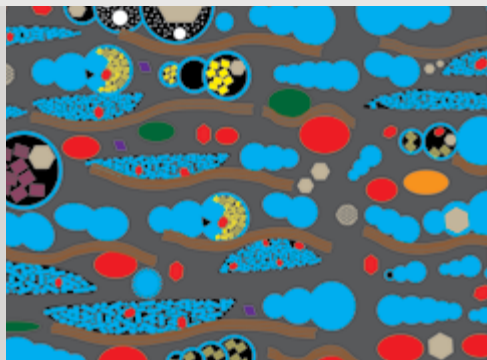
HotRock membership is \$75,000 a year. Companies will be able to collaborate with principal investigators and researchers, obtain all research results, and influence areas of research. Each member company will appoint a representative to the advisory board to help make strategic decisions on spending and research. HotRock will organize annual meetings attended by sponsors and other invited guests.

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## Mudrock Systems Research Laboratory



### Mission

The Bureau's Mudrock Systems Research Laboratory (MSRL) consortium brings together a broad spectrum of research expertise necessary to confront questions key to a better understanding of mudrock systems. The goal of the program is to integrate observations and data from nanoscale to basin scale using subsurface cores and outcrops along with machine learning tools to understand the static and dynamic interactions between rocks and fluids.

### Research Thrusts

MSRL's core-based research and workflow aims to understand fundamental processes impacting reservoir quality and deliverability. Our petrophysical labs not only measure porosity and permeability but are working toward advancing workflows to measure relative permeability and wettability. The inorganic geochemistry lab applies X-ray fluorescence and isotope geochemistry to better define facies and their continuity. The organic geochemistry lab measures gas adsorption, oil and gas compositions, thermal maturity, and biomarkers from rock extracts and produced fluids to understand the sources and quality of organic matter, to compare and correlate sources to produced fluids, and to help interpret the drainage rock volume. Reservoir heterogeneity in 3D was quantified using an integrated wireline log and chemofacies model validated by core-based lithofacies, which includes microscopic study of grain types, texture, and diagenesis.

### Research Challenges

Mudrock systems are reservoirs for unconventional resources, source rocks for conventional petroleum plays, caprocks and seals for conventional resources, and CO<sub>2</sub> and hydrogen storage in the subsurface. The current interest stems from the need to devise more efficient ways of extracting oil and gas from these reservoirs. Our challenge is to develop new methodologies and workflows for characterizing the dynamics of rocks and the fluids over production history.

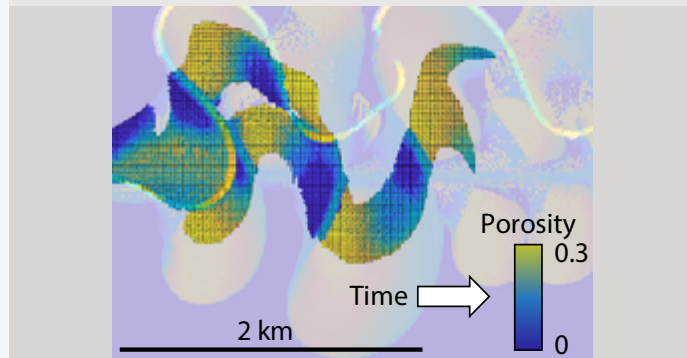
### Membership

Consortium members receive priority access to research data, interpretations, and reports. Results are distributed to members through annual workshops, seminars, short courses, and the internet.

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## Quantitative Clastics Laboratory



### Mission

The mission of the Quantitative Clastics Laboratory (QCL) is to develop a predictive understanding of processes and controls on sediment transport and the stratigraphic evolution of depositional systems, with applications in reservoir characterization, modeling, correlation, and source-to-sink predictions for frontier exploration.

### Research Thrusts

QCL researchers leverage the broad, world-class expertise of the Jackson School of Geosciences (JSG)—including collaborations with groups specializing in structural geology, Texas, and Gulf of Mexico depositional syntheses, seismic interpretation, and thermochronology—to address key challenges in the exploration and development of natural resources. These challenges include evaluation of reservoir presence and quality in data-limited frontier basins and characterization of reservoir connectivity and heterogeneity. The QCL has unique clastic research consortia access to industry subsurface data, including global seismic-reflection data sets and Bureau core repositories.

### Research Challenges

The QCL has two research themes: (1) reservoir-scale depositional system characterization, modeling, and flow simulation for a better understanding of processes that impact connectivity and heterogeneity; and (2) exploration-scale source-to-sink analysis to evaluate correlation, reservoir presence, and quality in the petroliferous Permian Basin and circum Gulf of Mexico. An exciting update to the QCL program is flow diagnostics analysis of digital stratigraphic models for evaluating the effect of stratigraphic evolution and facies architecture on fluid flow during production.

### Membership

Multiple meetings, workshops, and face-to-face consultations with industry members are held annually. The QCL offers industry members unique access to JSG expertise, industry subsurface data, investigations of multiple scales of depositional environments and their interconnections, and an evolving quantitative database on clastic depositional systems architecture.

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## Reservoir Characterization Research Laboratory



### Mission

The Carbonate Reservoir Characterization Research Laboratory's (RCRL) mission is to use outcrop and subsurface geologic, geophysical, and petrophysical data from carbonate reservoir strata as the basis for developing new and integrated methodologies and concepts to explain and describe the 3D reservoir environment and to improve hydrocarbon recovery factors. The RCRL is dedicated to technology transfer and education and consistently offers state-of-the-art training.

### Research Thrusts

The RCRL approaches reservoir characterization through four main scales of investigation: (1) platform-to-basin-scale stratigraphy; (2) reservoir architecture, including both matrix and nonmatrix systems (e.g., fractures and paleokarst); (3) structural- and geomechanical-properties characterization; and (4) pore networks and their reservoir distribution. Research questions are developed using both subsurface data and outcrop analogs. The RCRL emphasizes quantifying observations so that its research is applicable to reservoir models and is valuable in providing predictive relationships and conceptual tools for reservoir characterization and play analysis.

### Research Challenges

RCRL areas of investigation include Lower Permian shelf-to-basin stratigraphic and structural architecture of the Delaware and Midland basins; Gulf of Mexico carbonate reservoir settings, pore systems, fracture character, and margin variability; Cenozoic carbonate platform systems, high-resolution stratigraphy, and structural configuration of shelf margins; fractured carbonate reservoir characterization in outcrop and subsurface analogs; origin and petrophysics of tight limestone and dolomite reservoirs; regional reservoir characterization of the Austin Chalk trend; and carbonate rock mechanics and acoustic-properties research.

### Membership

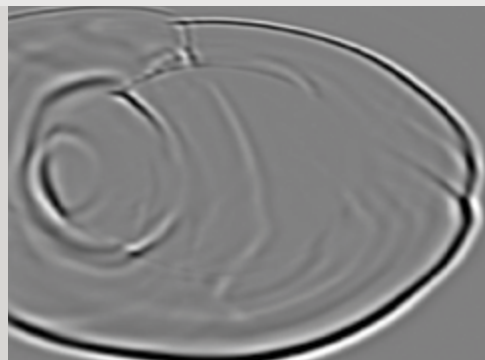
RCRL membership is \$55,000 per year. Sponsors are encouraged to commit to a two-year agreement (at \$50,000 per year) to better plan a longer-range research program.

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## Texas Consortium for Computational Seismology



### Mission

The mission of the Texas Consortium for Computational Seismology (TCCS) is to address the most important and challenging research problems in computational geophysics as experienced by the energy industry and to educate the next generation of research geophysicists and computational scientists.

### Research Thrusts

TCCS has pioneered new developments in several application areas: deep-learning methods for seismic interpretation, including automatic detection of lithofacies, faults, and geobodies; deep-learning methods for seismic data processing and imaging, including noise attenuation, computational wave propagation, and least-squares seismic migration; optimal transport methods for seismic full-waveform inversion; shaping regularization for improving acquisition and imaging with simultaneous sources; diffraction imaging for increasing the resolution of seismic imaging and reservoir characterization; seismic anisotropy and attenuation parameterizations for efficient imaging in complex media.

### Research Challenges

TCCS is a collaboration between the Bureau and the UT Oden Institute for Computational Engineering and Sciences. TCCS develops novel methods for seismic data analysis with focus on both resource exploration and carbon capture and storage. Areas of research focus include optimizing data acquisition with simultaneous sources, automating seismic interpretation, increasing the resolution of seismic reservoir characterization, and estimating subsurface properties using full-waveform inversion.

### Membership

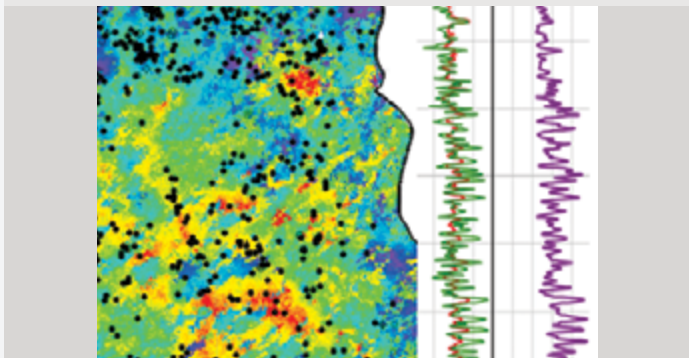
Each year, TCCS delivers two written reports and presents its findings to sponsors in two research meetings. TCCS publications follow the discipline of reproducible research: the results of each computational experiment are supplied with the open-source software code required for reproduction and verification.

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# Tight Oil Resource Assessment



## Mission

TORA's mission is to provide our stakeholders with reliable and up-to-date estimates, projections, play-scale geologic models, and insights at the basin scale for the major U.S. tight oil and shale gas plays by conducting innovative, integrated research of in-place resources and recoverable volumes, play and well economics, and production forecasts with their environmental implications.

## Research Thrusts

TORA employs a multidisciplinary, highly iterative evaluation process combining geoscience and engineering: (1) we create a basin-wide 3D facies architecture populated with petrophysical and geomechanical attributes and calculate in-place resources; (2) we model and match all well-production history before projecting future production, and we perform decline analysis using innovative in-house software; (3) we relate the productivity of existing wells to key subsurface and operational attributes to model the productivity of all undrilled locations; (4) we develop the full range of expected outcomes per well, including technological and cost improvements, pricing, logistics, drilling pace, well spacing, and lease accessibility; and (5) we use digital mapping to spatially link key geologic and operational practices to changes in per-well productivity. We also build sector-scale 3D subsurface models for focused studies and develop machine learning and physics-based workflows.

## Research Challenges

TORA aims to characterize unconventional reservoirs up to the basin scale, building integrated models and market independent production outlooks. Building on over a century of Bureau Permian research and data from over 30,000 horizontal wells, TORA studies tight oil and gas formations to produce unbiased, data driven, and comprehensive yet granular results. Our team continues to enhance our workflow to predict future productivity, hydrocarbon recoveries, economic viability, and play-wide production rates at a one square mile scale.

## Membership

TORA membership is \$60,000 annually as of September 2022.

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# ● ● Research Programs ● ●

## TexNet Seismic Monitoring Program

### Mission

The Bureau's TexNet seismic monitoring program is the State of Texas' earthquake analysis service. Funded by the State, TexNet operates the statewide network of over 150 seismometer stations, capturing vital information on seismic activity across Texas. TexNet hosts a skilled team of scientists and engineers who gather information and research the geologic and seismic data obtained by the network. The team also includes researchers from many public and private universities across the state.

### Program Thrusts

TexNet actively monitors earthquake activity across the State of Texas. TexNet members are also working on research in determining the causes of earthquakes and lessening any future impact from these events on people and property. TexNet provides the public with safety information, emergency agencies with earthquake facts important to first responders, public officials with assistance in decision-making regarding earthquake activity, regulatory agencies with solid data to inform policies, industry with information to shape earthquake safety and prevention practices, and researchers with reliable seismic data for answering complex scientific questions.

### TexNet Information

Earthquake data and earthquake monitoring information are now available through the interactive TexNet Earthquake Catalog at [catalog.texnet.beg.utexas.edu](http://catalog.texnet.beg.utexas.edu). Relocated high-resolution earthquake data is now available at [hirescatalog.texnet.beg.utexas.edu/](http://hirescatalog.texnet.beg.utexas.edu/). Also, injection of produced water volume information is available at [injection.texnet.beg.utexas.edu/](http://injection.texnet.beg.utexas.edu/).



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## State of Texas Advanced Oil and Gas Resource Recovery

### Mission

The mission of the Bureau's State of Texas Advanced Oil and Gas Resource Recovery (STARR) program is to conduct geoscience and engineering research to increase the profitability of earth resources within the State of Texas while encouraging responsible economic development and supporting education and environmental stewardship.

### Research Thrusts

Research thrusts of the STARR program and ongoing technology transfer to operators in the Texas energy industry are focused on: (1) carrying out integrated geoscience characterization studies relevant to the oil and gas industry; (2) developing improved oil recovery strategies, including optimization of waterfloods and CO<sub>2</sub> enhanced oil recovery; and (3) conceptualizing and developing geological, geophysical, and engineering projects to support the energy transition in Texas.

### Research Challenges

Challenges undertaken by the STARR team are wide and varied, ranging from explaining subsurface characteristics that control oil and gas production in Texas reservoirs to engineering challenges associated with identifying best enhanced recovery practices that have the potential for increasing oil and gas production in Texas oil fields. STARR challenges have expanded into the understanding of how Texas subsurface resources can be positioned to play a role in the ongoing energy transition, aiming at increasing the diversification and resilience of Texas' energy industries and its economy.

### Membership

No costs are associated with participation in the STARR program, which is funded by the State of Texas, although research matching support and willingness to facilitate publication of research results is encouraged.

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## Critical Minerals

Geopolitical and technology developments related to energy transitions and other societal changes have placed unprecedented global demands for metals, critical minerals, and industrial materials. The United States is heavily dependent on foreign sources for the vast majority of these materials, notably for the critical minerals that are key to energy production and storage and other aspects of technology advancement and national security.

The economic geology program at the Bureau is collaborating with industry and other state and federal entities to locate, assess, and catalog critical and other mineral resources within Texas and the Gulf Coast, making available data and related sample sets to promote exploration for and development of domestic mineral supplies.

These resource studies range from conventional metal resource settings such as West Texas magmatic-hydrothermal, Coastal Plain uranium, and Central Texas and Gulf Coast industrial and critical mineral systems. Current mapping efforts focused on critical minerals associated with igneous bodies in Trans-Pecos Texas are being supported by the cooperative federal and state components of the STATEMAP and Earth MRI programs. These efforts follow the 2021 completion of a regional airborne geophysical survey flown by the U.S. Geological Survey.

In addition, unconventional sources of critical minerals such as lithium from produced waters, rare earth elements in Gulf Coast lignites, coal power plant ash, bauxite residue, and historic mine wastes are being studied. Domestic supply chain security and related environmental concerns require innovation to responsibly source key mineral resources to support large-scale energy and infrastructure development for the growing Texas population.

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## STATEMAP

Bureau mapping efforts continue to expand in response to the new U.S. GeoFramework Initiative to prepare seamless, three-dimensional geologic maps and models of the United States by 2030. Bureau researchers, illustrators, and editors have produced 10 new geologic maps and geodatabases for the most recent installment in the long-running STATEMAP program. STATEMAP is a core element of the National Cooperative Geologic Mapping Program administered by the U.S. Geological Survey. The Bureau's mapping efforts are also supported by the State of Texas Advanced Resource Recovery (STARR) program and the Jackson School of Geosciences, which provide funding that matches the federal support in this cooperative program.

Since STATEMAP began in the 1990's, 259 geologic maps have been published in the Bureau's Open-File Maps series, along with several compilation maps in the peer-reviewed Miscellaneous Maps series. All maps are available through The Bureau Store.

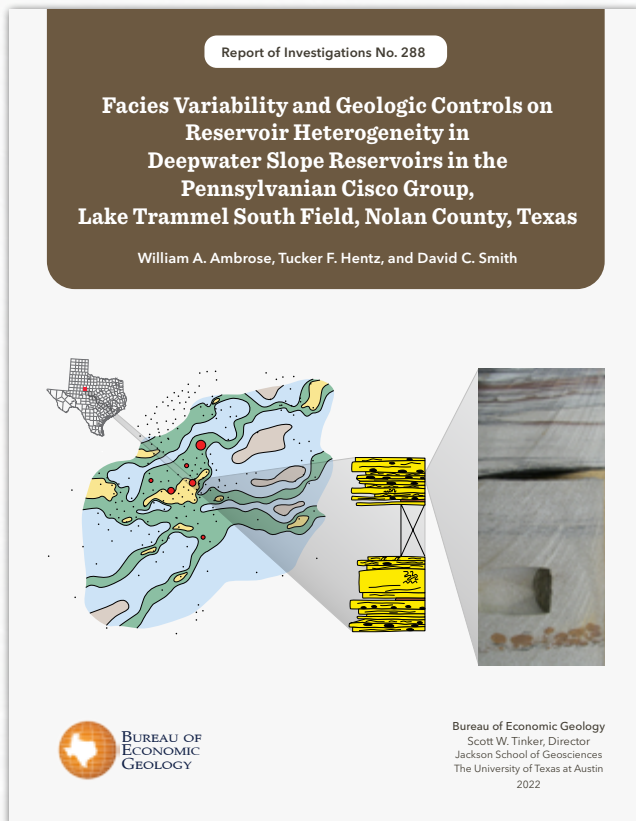
This year's new maps include the High Island and Mud Lake quadrangles in the Galveston Bay area, the Palacios NE and Palacios SE quadrangles in the Matagorda Bay area, and the Mason, Turtle Creek, and Creedmoor quadrangles in Central Texas. In addition, two 1:100,000-scale compilation maps were completed for the Pedernales Falls area in Central Texas and the Matagorda Bay area on the Coastal Plain. The coastal quadrangles document the relationships among geologic units deposited and modified during major sea level changes during repeated glacial and interglacial cycles of the late Pleistocene and Holocene eras. The Central Texas quadrangles focus on water and mineral resources and on geologic units relevant to rapidly changing land-use patterns in the Central Texas urban growth corridor (Creedmoor). Major contributors to the recent mapping effort include **Tiffany Caudle, Lucie Costard, Brian Hunt, Jeffrey Paine** (Principal Investigator), and **Chock Woodruff**. Bureau graphics and editing staff **Jana Robinson, Francine Mastrangelo, Nancy Cottingham,** and **Jason Suarez** prepared the maps for publication.

Geologic mapping efforts have begun in the Trans-Pecos region under the Earth MRI program to help evaluate potential critical mineral resources that have seen increased demand as energy sources diversify and electric storage needs intensify.

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# ● ● Publications ● ●



## Facies Variability and Geologic Controls on Reservoir Heterogeneity in Deepwater Slope Reservoirs in the Pennsylvanian Cisco Group, Lake Trammel South Field, Nolan County, Texas

Ambrose, W. A., Hentz, T. F., and Smith, D. C., 2022, Facies variability and geologic controls on reservoir heterogeneity in deepwater slope reservoirs in the Pennsylvanian Cisco Group, Lake Trammel South field, Nolan County, Texas: The University of Texas at Austin, Bureau of Economic Geology Report of Investigations No. 288, 35 p., doi.org/10.23867/RI0288D.

Report of Investigations 288 is a detailed study of clastic-slope reservoirs in the Virgilian-Wolfcampian Cisco Group in Lake Trammel South field in Nolan County, Texas in the Eastern Shelf of the Permian Basin. Integrating core, wireline log, and oil production data, this study provides detailed facies descriptions and net-sandstone maps of more than 10 reservoir units. Slope reservoirs in Lake Trammel South field are compared to examples of other reservoirs with similar depositional origin in other basins for geologic context. The study also identifies and discusses three levels of reservoir heterogeneity (microscale, meso-scale, and macroscale) and their impact on sandstone-body continuity, reservoir compartmentalization, and the potential for additional hydrocarbon recovery in the field.



To purchase any of these publications, visit The Bureau Store: <https://store.beg.utexas.edu/>

Bureau's Open-File Maps series, along with several compilation maps in the peer-reviewed Miscellaneous Maps series. All maps are available through The Bureau Store.

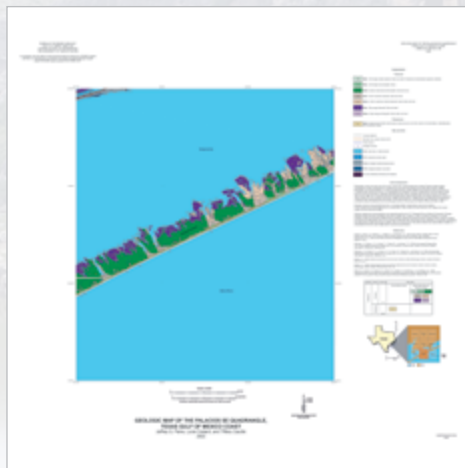


**Geologic Map of the High Island Quadrangle, Texas Gulf of Mexico Coast**  
Caudle, T. L., Paine, J. G., and Andrews, J., 2022: The University of Texas at Austin, Bureau of Economic Geology Open-File Map No. 256, scale 1:24,000.

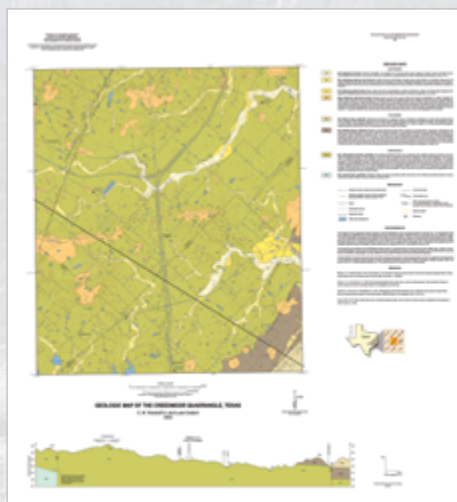


**Geologic Map of the Palacios NE Quadrangle, Texas Gulf of Mexico Coast**  
Paine, J. G., and Costard, L., 2022: The University of Texas at Austin, Bureau of Economic Geology Open-File Map No. 257, scale 1:24,000.

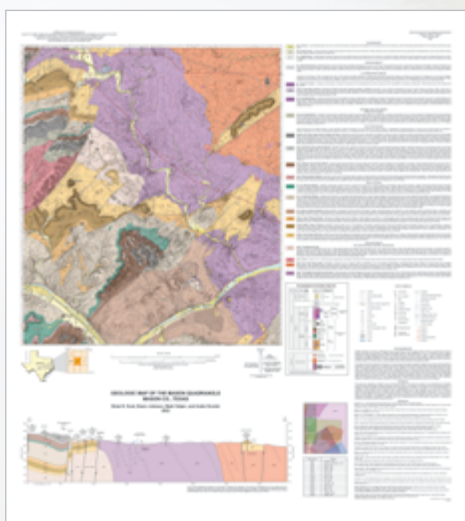




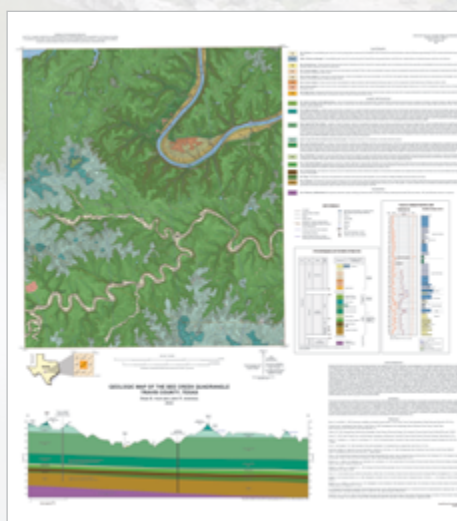
**Geologic Map of the Palacios SE Quadrangle, Texas**  
Paine, J. G., Costard, L., and Caudle, T. L., 2022: The University of Texas at Austin, Bureau of Economic Geology Open-File Map No. 258, scale 1:24,000.



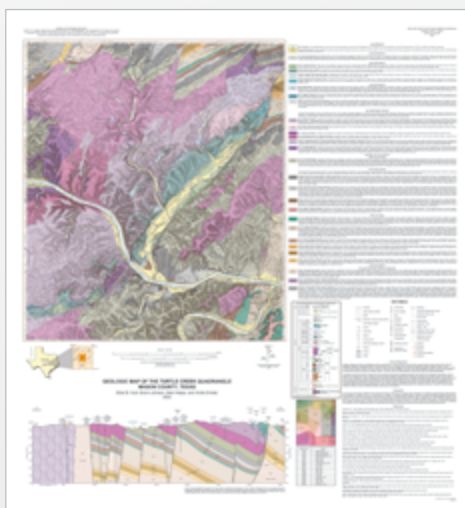
**Geologic Map of the Creedmoor Quadrangle, Texas**  
Woodruff, C. M., Jr., and Costard, L., 2022: The University of Texas at Austin, Bureau of Economic Geology Open-File Map No. 261, scale 1:24,000.



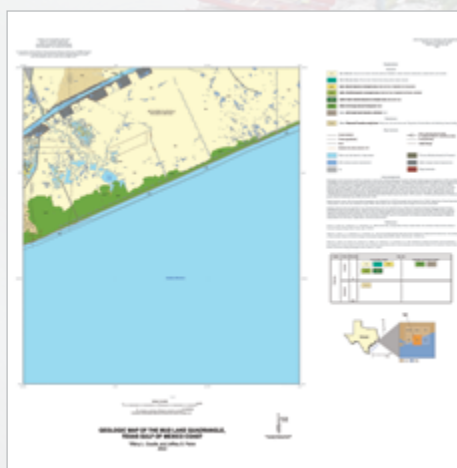
**Geologic Map of the Mason Quadrangle, Mason County, Texas**  
Hunt, B. B., Johnson, B., Helper, M., and Droxler, A., 2022: The University of Texas at Austin, Bureau of Economic Geology Open-File Map No. 259, scale 1:24,000.



**Geologic Map of the Bee Creek Quadrangle, Travis County, Texas**  
Hunt, B. B., and Andrews, J. R., 2022: The University of Texas at Austin, Bureau of Economic Geology Open-File Map No. 264, scale 1:24,000.



**Geologic Map of the Turtle Creek Quadrangle, Mason County, Texas**  
Hunt, B. B., Johnson, B., Helper, M., and Droxler, A., 2022: The University of Texas at Austin, Bureau of Economic Geology Open-File Map No. 260, scale 1:24,000.



**Geologic Map of the Mud Lake Quadrangle, Texas Gulf of Mexico Coast**  
Caudle, T. L., and Paine, J. G., 2022: The University of Texas at Austin, Bureau of Economic Geology Open-File Map No. 265, scale 1:24,000.

# Peer-Reviewed Publications by Bureau Researchers

Acevedo, J. P., Lemons, C. R., Young, M. H., McDaid, G., and Scanlon, B. R., 2022, Analysis of wastewater injection and prospect regions for induced seismicity in the Texas panhandle, United States: AAPG Bulletin, v. 106, no. 4, p. 679–699, <https://doi.org/10.1306/EG.01072120005>.

Ambrose, W. A., Hentz, T. F., and Smith, D. C., 2022, Facies variability and geologic controls on reservoir heterogeneity in deepwater slope reservoirs in the Pennsylvanian Cisco Group, Lake Trammel South field, Nolan County, Texas: Austin, Tex., The University of Texas at Austin, Bureau of Economic Geology, Report of Investigations, v. 288, 35 p., ISBN 978-1-970007-39-8, <https://doi.org/10.23867/RI0288D>.

Arciniega-Esparza, S., Hernández-Espriú, A., and Young, M. H., 2022, Implications of unconventional oil and gas development on groundwater resources: Current Opinion in Environmental Science and Health, v. 27, no. 100346, 9 p., <https://doi.org/10.1016/j.coesh.2022.100346>.

Bhattacharya, S., 2022, Unsupervised time series clustering, class-based ensemble machine learning, and petrophysical modeling for predicting shear sonic wave slowness in heterogeneous rocks: Geophysics, v. 87, no. 5, p. D161–D174, <https://doi.org/10.1190/geo2021-0478.1>.

Bhattacharya, S., Ambrose, W., Ko, L. T., and Casey, B., 2022, Integrated detection and investigation of bad borehole section in the Wolfcamp Formation in the Midland Basin using machine learning, petrophysics, and core characterization: Interpretation, v. 10, no. 3, p. C19–C27, <https://doi.org/10.1190/INT-2021-0165.1>.

Bihani, A., Daigle, H., Santos, J. E., Landry, C., Prodanović, M., and Milliken, K., 2022, MudrockNet: semantic segmentation of mudrock SEM images through deep learning: Computers & Geosciences, v. 158, no. 104952, 10 p., <https://doi.org/10.1016/j.cageo.2021.104952>.

Bryndzia, L. T., Day-Stirrat, R. J., Hows, A. M., Nicot, J.-P., Nikitin, A., and Huvaz, O., 2022, A geochemical analysis of produced water(s) from the Wolfcamp formation in the Permian Delaware Basin, western Texas: AAPG Bulletin, v. 106, no. 6, p. 1265–1299, <https://doi.org/10.1306/01282220180>.

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Burnham, B. S., Bond, C. E., Flaig, P. P., van der Kolk, D. A., and Hodgetts, D., 2022, Outcrop conservation: promoting accessibility, inclusivity, and reproducibility through digital preservation: The Sedimentary Record, v. 20, no. 1, p. 5–14, <https://doi.org/10.2110/sedred.2022.1.2>.

Burnham, B. S., Flaig, P. P., Brice, R. R., Spagnolo, M., and Young, M. H., 2022, Rapid sediment re-deposition may limit carbon release during catastrophic thermokarst lake drainage: GSA Today, v. 32, no. 5, p. 60–61, <https://doi.org/10.1130/GSATG529GW.1>.

Chen, W., Liu, X., Saad, O. M., Oboué, Y. A. S. I., Yang, L., Wang, H., and Chen, Y., 2022, 3-D seismic diffraction separation and imaging using the local rank-reduction method: IEEE Transactions on Geoscience and Remote Sensing, v. 60, no. 4507110, 10 p., <https://doi.org/10.1109/TGRS.2021.3139314>.

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# ● ● Transitions ● ●



**Sigrid M. Clift**  
Public Information  
Geologist

Sigrid Clift had an incredible 24-year career at the Bureau of Economic Geology. A prolific author, Sigrid was lead or secondary author of numerous publications. Her work comprised many research projects, and during her last 15 years she served as the Bureau's Public Information Geologist. In this role, Sigrid frequently appeared in various media outlets, responding to all questions related to geology. For her contributions, she earned a number of awards including the Jackson School of Geosciences' Outstanding Staff Award and Outstanding Service Award. Sigrid especially enjoyed her work in education outreach, particularly GeoFORCE, a K-12 outreach program designed to increase the number and diversity of students pursuing STEM degrees and careers, especially the geosciences. An enduring theme throughout Sigrid's career was her admiration for colleagues and the pleasure she derived from working in collaboration with others.

## In Memoriam



**Auburn L. Mitchell**  
Associate Director

Auburn L. Mitchell was an attorney, specializing in natural resources and energy. He served as Counsel to Mack Wallace, Chairman of the Texas Railroad Commission, followed by serving as energy advisor to Governor Bill Clements. He continued to serve the State of Texas throughout his career, taking positions at the Bureau of Economic Geology, the Railroad Commission of Texas, the Texas Commission on Environmental Equality, and finally in the office of Governor Rick Perry. As associate director for the Bureau's environmental division, Mitchell supported the State's role in the cleanup of the Pantex Plant and ultimately led the project to produce excellent results.



**Bruno Vendeville**  
Senior Research  
Scientist

Bruno Vendeville held the position of research associate at the Bureau of Economic Geology. He stayed in Texas until 2004, a time during which he was ultimately promoted to senior research scientist. While in Austin, he built his first analog modeling laboratory, a research facility dedicated to the experimental study of interactions between salt tectonics and crustal tectonics. He was held in high esteem by the international community of salt tectonics for the great importance and influence of his research work and for the loving kindness he would offer to everyone.

## New Employees

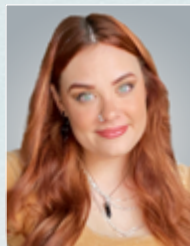
The Bureau of Economic Geology continues to attract some of the most talented geoscientists in the world to conduct impactful research on a wide range of energy and environmental questions—and equally talented support staff to help them in their efforts. The year 2022 was no exception as the Bureau brought a diverse group of 30 new people on board. Please help us welcome them to the Bureau!



**Chas Bolton**  
Research Scientist  
Associate III



**Hassan Dashtian**  
Research  
Associate



**Erin DeConcini**  
Human Resources  
Representative



**Reza Ershadnia**  
Modeler/Data  
Scientist Postdoc



**Preston Fleck**  
Field Engineer  
Seismologist



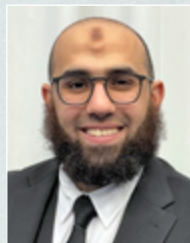
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Events Program  
Coordinator



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Lee**  
Postdoctoral Fellow



**Wonhyun Lee**  
Research  
Associate



## New Employees *(continued)*



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Fellow



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Research Scientist  
Associate III



**Ander  
Martinez-Donante**  
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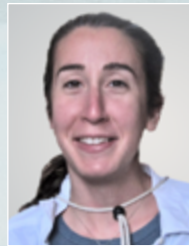
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Associate



**Leopoldo Ruiz**  
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**Michael Wang**  
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**Carson Werner**  
Publications Sales  
Associate



**Katy Yut**  
Energy Data and  
GIS Analyst

## Living Memorials

In an effort to recognize the lasting contributions of past employees through a living monument, the Bureau adopted the Memorial Tree Program in 2013. Since its inception, donations by Bureau employees have underwritten the planting of a tree in commemoration of employees whose passing occurred or was noted during the year. The program is administered by The University of Texas at Austin as part of its Memorial Tree Program; an interactive map can be found at <https://facilitieservices.utexas.edu/divisions/support/urban-forestry/memorial-trees-map>.





# • • 2022 • • Visiting Committee

The Bureau of Economic Geology's Visiting Committee includes leaders from industry, State agencies, academia, and nonprofit organizations, each with a keen interest in furthering the work of the Bureau and the many ways it serves the public by undertaking impactful energy, environmental, and economics research that matters.

The Bureau's Visiting Committee came together in August for a virtual annual meeting, and 14 members participated. The Committee was briefed by Director **Scott W. Tinker** and five senior researchers on how the Bureau has recently faced new challenges presented by the evolving landscapes of the global economic and energy situations. Topics included innovative Bureau research into hydrogen storage and technologies, the full life cycles of electricity generation, and geothermal energy. A broad new relationship with University Lands was also discussed, as were the TexNet and geologic mapping programs. Committee members provided thoughtful insights into potential research thrusts and untapped funding resources, and their perspectives on the Bureau's research and activities were invaluable.

For more information about the work of the Bureau or its Visiting Committee, please contact **Mark W. Blount, External & Governmental Affairs**, [mark.blount@beg.utexas.edu](mailto:mark.blount@beg.utexas.edu).



**From top left to right:** Dr. Claudia Hackbarth, Chair (Shell Global, retired), Mr. Elliott Pew (Enerplus Corporation, retired), Mr. Tim Brittan (Infinity Oil & Gas, Inc.), Chairman Jon Niermann (Texas Commission on Environmental Quality), Ms. Korry Castillo (Texas Comptroller of Public Accounts), Ms. Carol Lloyd (ExxonMobil Corporation), Mr. John Gibson, Jr. (Flotek), Mr. Bud Brigham (Anthem Ventures, Brigham Minerals, Brigham Exploration, Atlas Sand), Mr. James "Jim" Farnsworth (Beacon Offshore, Azimuth Capital), Dr. Dan Domeracki (UNC Kenan-Flagler Business School), Mr. William "Billy" Murphy (University Lands), Dr. Scott W. Tinker (Bureau of Economic Geology), Mr. Michael "Mike" Ming (Ming Energy Partners, LLC), Mr. Bud Scherr (Valence Operating Company), and Mr. Bill Black (Railroad Commission of Texas, represented Commissioner Christi Craddick).



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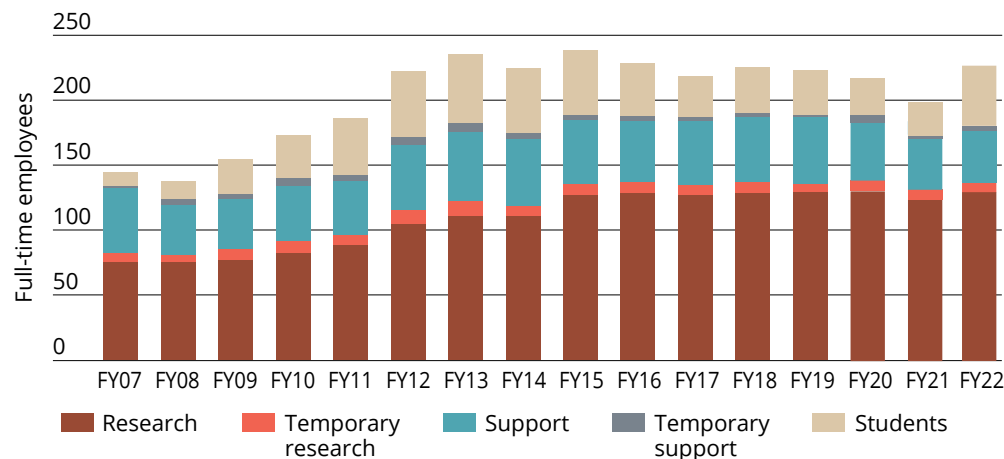
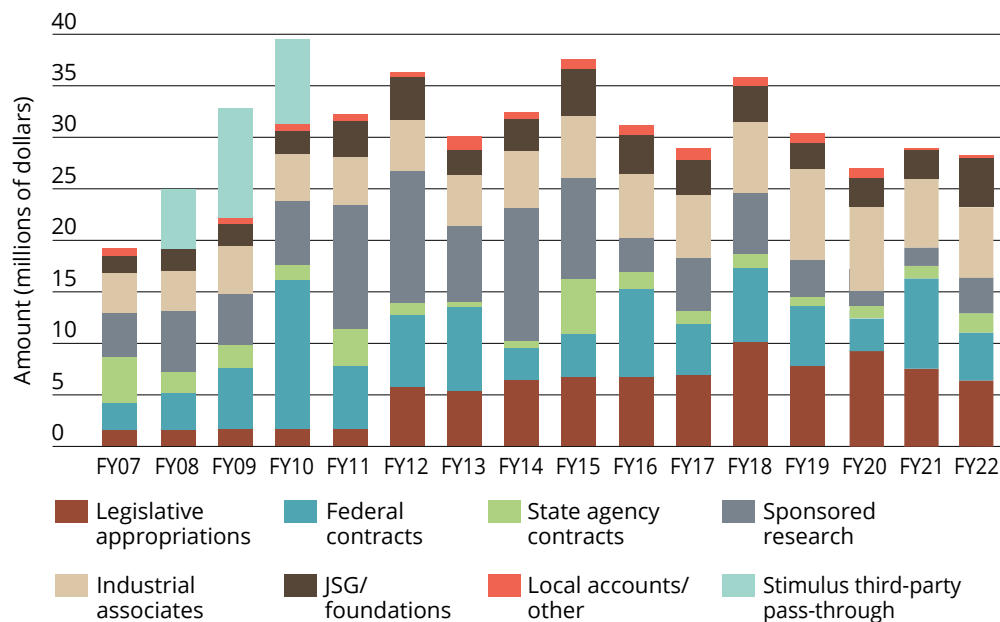
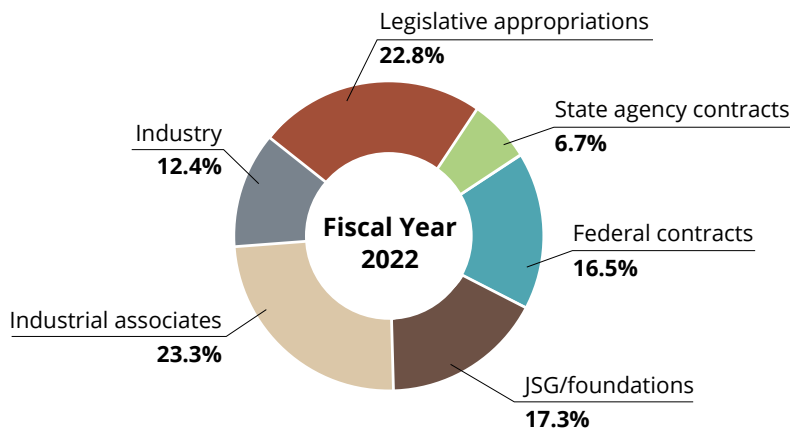
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