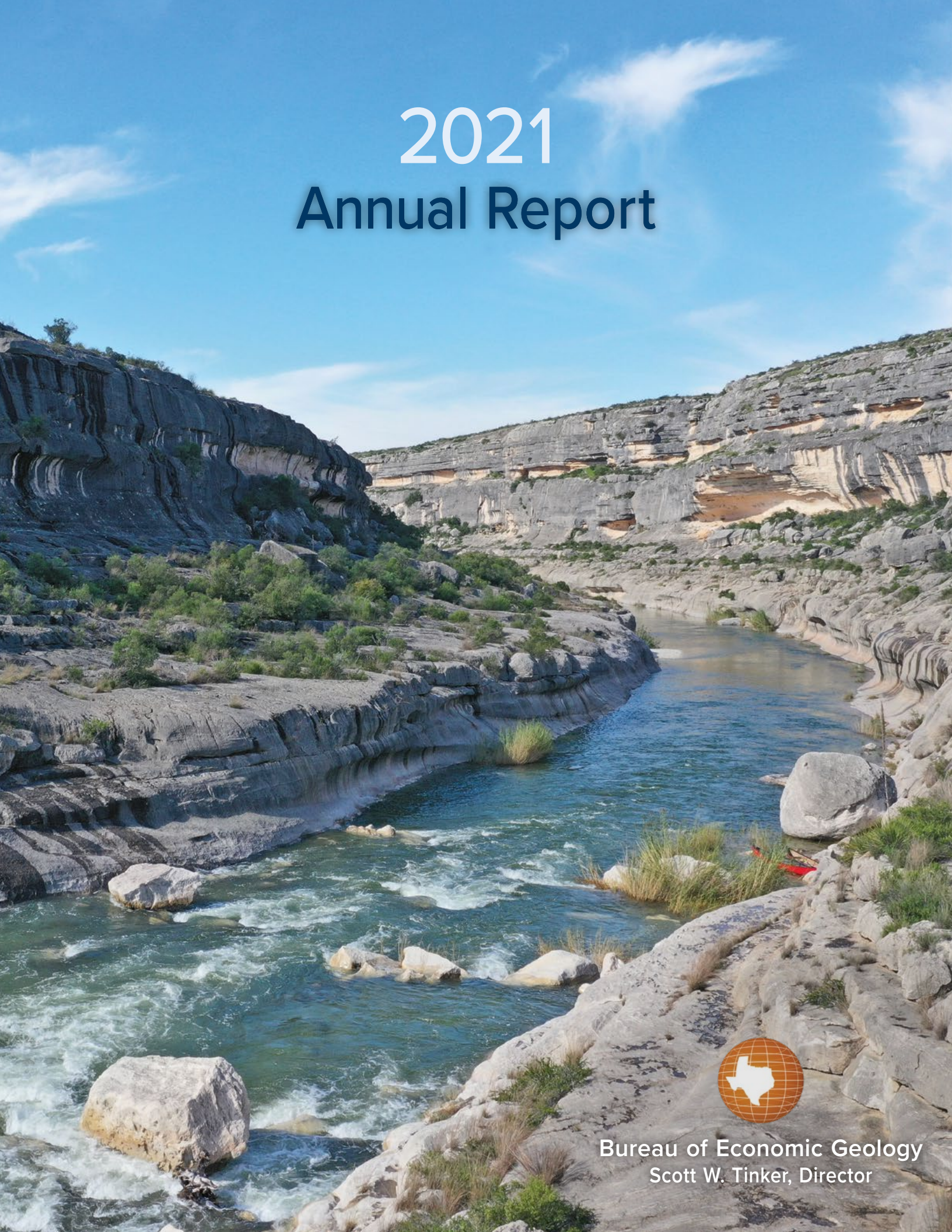
2021
Annual Report



Bureau of Economic Geology
Scott W. Tinker, Director

Message from the Director

One reality in life is that we only move forward. We can't go back, and we can't stand still. The past is there to learn from, and the present to immerse in, and hopefully enjoy. But the future has yet to be determined, and we have some influence over how that goes.

The past two years have been difficult. We have lost loved ones and friends, adapted to new work and home realities, and in some ways struggled to find our sense of who we are as people. Yet rising above this languishing cloak is a remarkable sense of camaraderie. Examples at the Bureau abound that illustrate a true sense of care for one another, which are at once uplifting and empowering. In what seems to be presented as an ever-polarizing world, we are in fact coming together. There is little more powerful.

There is also, perhaps, some semblance of comfort knowing that we are not the first to face adversity. Our parents and grandparents faced major challenges as well, and they weathered those crises and came out stronger for the effort. What we learn from their struggles, and our own, is that very few, if any, crises are so immediate that they preclude thoughtful discourse and analysis prior to action. Because no one owns the moral high ground, intentions, no matter how passionate, should not, cannot, coerce rushed outcomes. Especially in science. In other words, we can be thoughtful. We must be thoughtful.

As we move forward in the Bureau, we do so with humility, knowing that we are always learning, adapting, and growing. Solid, lasting science will not be hurried by political desire. We have time.

Contents

Cover image:
Painted Canyon, Pecos River, Texas.
Courtesy of Chris Zahm.

Moving Forward

The year 2020 at the Bureau of Economic Geology may be remembered as perhaps the finest hour in its long history. Resolute and forward-looking leadership and resilient staff adapted to and overcame the perfect storm of COVID-19 and all of its formidable impacts, the oil price decline's damage to the energy industry and subsequent draw down of industry research funding, and the severe restriction on staff to get into the field and labs to conduct their work.

We used the time to adjust our sails and create new programs and opportunities. As such, although the drastic operational changes wrought by the pandemic and forced budget belt-tightening persisted, 2021 saw the first steps on the Bureau's road to recovery and the pursuit of a host of promising new research initiatives. The year 2021 was one of moving forward.

To be sure, 2021 did not come without challenges. Safety protocols for protection against the virus remained in place for much of the year, and the majority of the staff did not return to the office until October. We lost one of our own to COVID-19 in May, David Boling of the Bureau's business office (see page 31). We had support from all our major sources cut. Yet staff and researchers stepped up to tackle each challenge, and we pressed on!

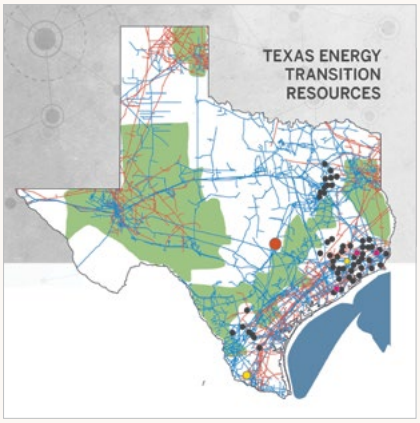
Emerging from the year were the positive fruits of broad efforts to identify new funding opportunities. Researchers planned and implemented innovative programs and projects suited for the reality of a new landscape in energy, environmental, and energy economics research. The new initiatives fell within the context of the Bureau's overarching objective to address the dual challenge of research designed to help supply the world with affordable, reliable energy, while also lowering emissions and minimizing the impacts of all forms of energy on land, air, and water. These major initiatives have attracted supporters from industry, government, and the private sector to our work. Highlights of several programs, some brand new and others adapted to the times, follow.

Comparing Electricity Options

The current transition of electricity generation from high-density, baseload, dispatchable sources like coal, natural gas, and nuclear to intermittent, low-density sources like wind and solar is occurring in some parts of the developed world. This will require a significant expansion of the global supply chain for critical materials and other mined materials needed for future solar and wind energy production. It will touch all dimensions of the environment, social, and governance framework. However, a comprehensive understanding of potential environmental and societal impacts is lagging, increasing the risk of significant unintended consequences and potentially derailing development of effective solutions. The Comparing Electricity Options (CEO) research consortium is an initial three phase, data-driven life cycle analysis of local- and global-environmental impacts associated with electricity generation plants and associated supply chains of select materials needed for developing gas-fired, wind and solar power plants and batteries. It will include end user costs of electricity and the social cost of externalities under various scenarios of generation portfolios.

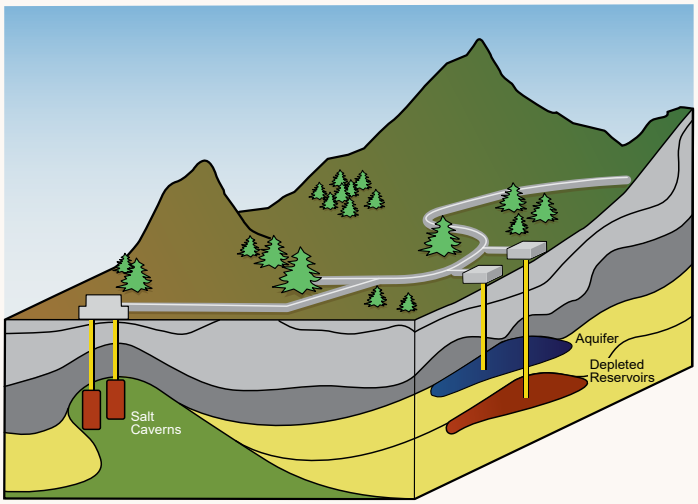
Permian Energy Transition Lab

Over the last several years, the US government, technology companies, and universities have discussed ways to reduce carbon emissions. Regardless of the suite of technologies that might be deployed and brought to market, it is apparent that bench-scale testing will not be sufficient. Recent discussions with, and funding from, the Cynthia and George Mitchell Foundation, has initiated activities toward creation of a new field laboratory, called the Permian Energy Transition Lab @ University Lands (PETL), and formation of new UT Austin programs that would guide and accelerate technology readiness. PETL would leverage the significant Earth science knowledge and research that has been conducted by the Bureau for decades, becoming a foundation for cross-campus collaboration in field deployment and testing.



$GeoH_2$

Hydrogen (H_2) offers the potential for a transportable, storable fuel for a low-carbon economy. $GeoH_2$, a new research consortium led by the Bureau, focuses on geological storage of hydrogen, techno-economics, and novel subsurface concepts such as in situ generation of hydrogen from oil fields to answer critical questions to enable and optimize possible hydrogen value chains. Additional support would develop field and laboratory experimentation to better constrain models and test designs to inform demonstration projects and scale hydrogen. The recent federal infrastructure funding contains several billion dollars for hydrogen research and projects.

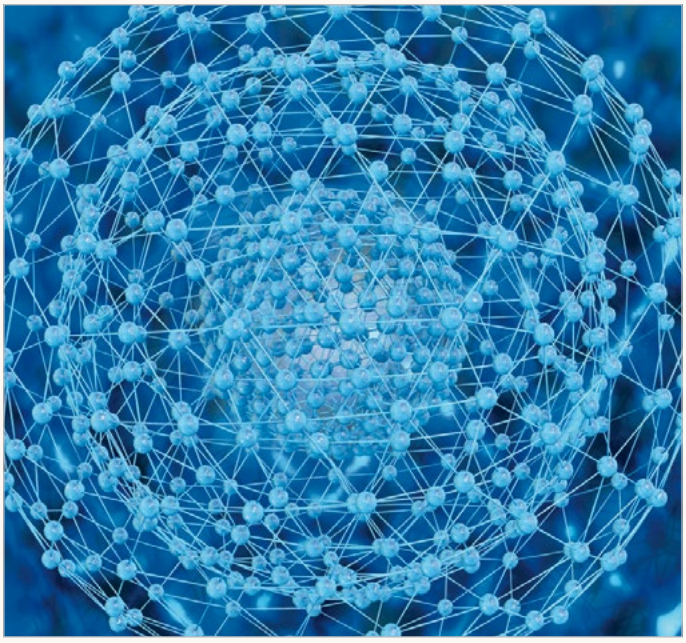


Geothermal

Geothermal energy is emerging in the eyes of energy producers, power companies, venture capitalists, policy and economics analysts, and even the military as a potential baseload energy source. This is due largely to advances in oil- and gas-drilling technology, which in turn make geothermal a ready pivot for the worldwide energy industry skill and equipment set. Texas has been a leader in multiple energy revolutions and is taking the leading steps toward a new geothermal industry. The Bureau is out in front with a new assessment of Texas' geothermal potential and the likely first commercial geothermal plant east of the Rockies, funded by the U. S. Air Force and located in Houston.

Advanced Energy Consortium

Over the last decade, the Bureau has been a pioneer in developing micro- and nano-scale sensors and materials to help illuminate the subsurface. Our research enables the remote monitoring of subsurface processes for environmental health, safety, energy, security, and structural integrity. Specific applications include carbon dioxide (CO_2) sequestration, H_2 storage, geothermal, pipeline surveillance, environmental monitoring, cement integrity, enhanced oil recovery, and more. The development of distributed, real time, miniaturized subsurface sensors and materials, with the associated data analytics, are helping to revolutionize the way we address the emission transition. The Advanced Energy Consortium (AEC) has invested over $60 million in research funding since its inception among dozens of global universities and has 40 patents, 275 publications, and 32 university and research partners.



Keep up with the latest from the Bureau

Twitter: @Bureau3E

LinkedIn: www.linkedin.com/company/bureau-of-economic-geology

YouTube: https://www.youtube.com/c/BureauofEconomicGeology

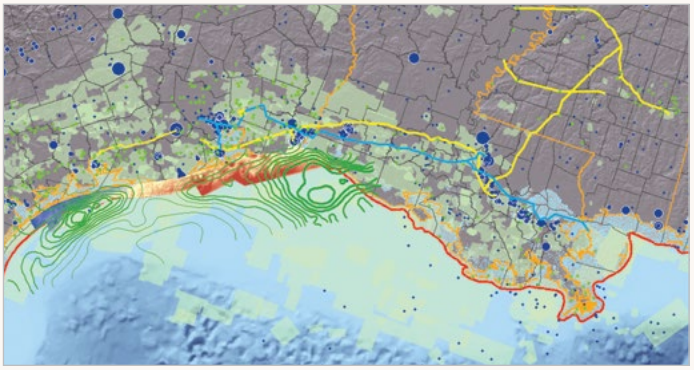
EarthDate: https://www.earthdate.org/

Researchers' Corner: https://www.beg.utexas.edu/news/researchers-corner

News: www.beg.utexas.edu/news/articles

Gulf Coast Carbon Center

The Bureau has a multi-decade, multi-discipline national leadership role in carbon capture, utilization and storage (CCUS) having led the research projects injecting CO_2 into brine at Frio in Texas, Cranfield on the Louisiana-Mississippi border, in the Texas offshore, and other global locations. The Gulf Coast Carbon Center (GCCC) at the Bureau has attracted over $50 million in funding to date and sees considerable potential to grow that. The recent federal infrastructure funding contains several billion dollars for CCUS research and projects.



Critical Minerals

Rapid development of technology and growing demand for solar and wind is increasing global demand for metals, minerals, and industrial materials. The United States is heavily reliant on imports of over 35 metals and minerals now termed critical minerals by the federal government. The economic geology program at the Bureau is utilizing collaboration with industry and public entities to locate, categorize, and catalog critical mineral resources within the State of Texas and Gulf Coast to provide publicly available data sets with the goal of promoting exploration and development of supply chains in the state and the U.S. These resource investigations range from conventional sources such as West Texas volcanics to coastal plain uranium deposits, as well as unconventional sources of metals and minerals in Gulf Coast lignites, coal power plant ash waste, bauxite red mud, and historic mine tailings. For reasons including supply chain security, human rights, and environmental impact minimization, the U.S. will need to consider mining again if it pursues large-scale solar and wind.

News and Events

Geothermal Anywhere—Texas' Next Great Energy Opportunity

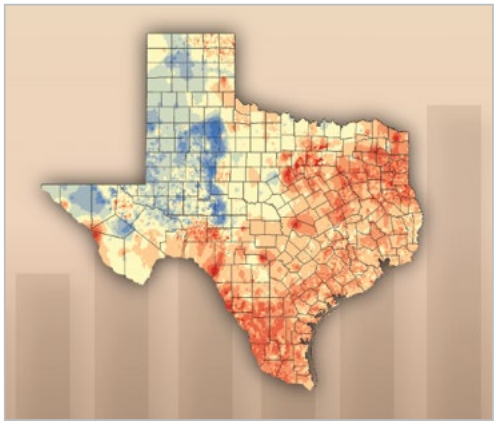
We look forward to the next energy revolution, one that Texas could lead for the world—geothermal power anywhere.

Recent and continuing advances are changing the status quo and opening the door for Texas to add a major new power source to its grid and to develop a major new industry—new-paradigm geothermal. Advances in technology are breaking the old geographic constraint on where geothermal power can be developed and are putting in place a new paradigm: geothermal anywhere. In light of this new paradigm, the Bureau is beginning to reexamine the geothermal potential of Texas. This effort is funded by the Cynthia and George Mitchell Foundation through a grant to the Energy Institute at the University of Texas at Austin.

The major difference between this study and previous work is the inclusion not only of conventional hydrothermal and geopressure, but geothermal anywhere, too. Geothermal anywhere opens up all of Texas, not just select areas, to geothermal power production. Geothermal anywhere will even demand new methods of city planning. When power generation is embedded in a decentralized, organic way at the scale of about 10 MW per plant, policymakers must fold such power infrastructure into growth plans.

Besides the statewide resource assessment, the Bureau is a major part of a DOE project to geothermally heat the Cornell University campus with a low enthalpy geothermal system. Steve Laubach leads the Bureau's fracture research group and provides critical expertise to the project.

Interest is also skyrocketing in an area that could be a major component of geothermal anywhere—the reuse or repurposing of existing (or depleted) oil and gas fields. Texas is a pincushion of hundreds of thousands of wells, and deep oil and gas–producing basins are now coming into viability as geothermal producers thanks to the changing energy economics and the technology advances that are enabling geothermal anywhere. Two key aspects make oil and gas fields attractive: (1) Some fields are relatively deep and reach bottom-hole temperatures of 150°C (~300°F) or higher, generally considered a solidly viable temperature for electricity production given current technology.



(2) Infrastructure, particularly wells, is already in place, greatly reducing up-front costs.

Other, private geothermal projects are in the works in Texas, and readers should watch for announcements as projects receive funding and go public.

TexNet and the Center for Integrated Seismicity Research Hold Annual Review

The Bureau of Economic Geology's TexNet Earthquake Monitoring Program and the Center for Integrated Seismicity Research (CISR) conducted their sixth consecutive joint Annual Review recently. The meeting focused on a comprehensive review of progress made on the monitoring of the increasing rate of induced earthquakes in Texas and research into causes, the evolving hazard, and mitigation.

The stakeholder groups in attendance included representatives of the CISR Science Advisory Committee and their colleagues from the 22 CISR upstream and midstream sponsor companies (the largest number of companies to date); the Texas Governor's TexNet Technical Advisory Committee; technical staff from the Texas Railroad Commission; and the extended TexNet and CISR operations and research teams from five academic units at UT, Southern Methodist University, UT El Paso, and New Mexico Tech.

Led by Peter Hennings, Principal Investigator of CISR, and Alexandros Savvaidis, TexNet Manager and Principal Investigator, the meeting consisted of general reviews of TexNet and CISR objectives, monitoring and research investment strategy, and research progress. It was a highly informative and constructive meeting, and there was a widespread consensus that the initial vision to create a TexNet–CISR collaboration across the principle stakeholder groups has become a reality.

Bureau Undertaking Study to Develop Geothermal Energy at Ellington Air Force Base

The Bureau of Economic Geology, in collaboration with Texas-based geothermal energy company Sage Geosystems, has been selected by the U.S. Air Force to perform a feasibility study in cooperation with the Texas Air National Guard on the deployment of closed-loop geothermal energy systems to supply clean and secure power to Ellington Field Joint Reserve Base in Houston, Texas. The funding is a Small Business Technology Transfer Phase I award from the Air Force AFWERX innovation program. The study is currently in Phase II with the expectation of moving to Phase III next year and will break ground within two years. TexNet has also set up a specific seismic monitoring network for the project.

Ken Wisian studies a rock sample through a microscope in the Bureau of Economic Geology mineral studies lab.

The Bureau will provide scientific support for the project, including detailed resource and geology assessments. **Ken Wisian**, Associate Director of the Bureau's Environmental Division and former Air Force Major General, will represent the Bureau in the project. "This pilot has the potential to prove the economic viability of a new paradigm of geothermal power generation anywhere," Wisian noted.

The systems being pioneered by Sage, a newly launched geothermal venture led by former oil and gas industry executives, are attractive to the military for their small physical footprint, grid independence, security and nonreliance on supply chains, and sustainability. The Texas National Guard hopes the feasibility study will result in a geothermal power facility at a military installation in Texas in the near term. "The work being conducted by Sage Geosystems is of critical interest to our organization to ensure based energy resiliency," remarked the National Guard program director. Sage is a graduate venture of UT Austin's Geothermal Entrepreneurship Organization.

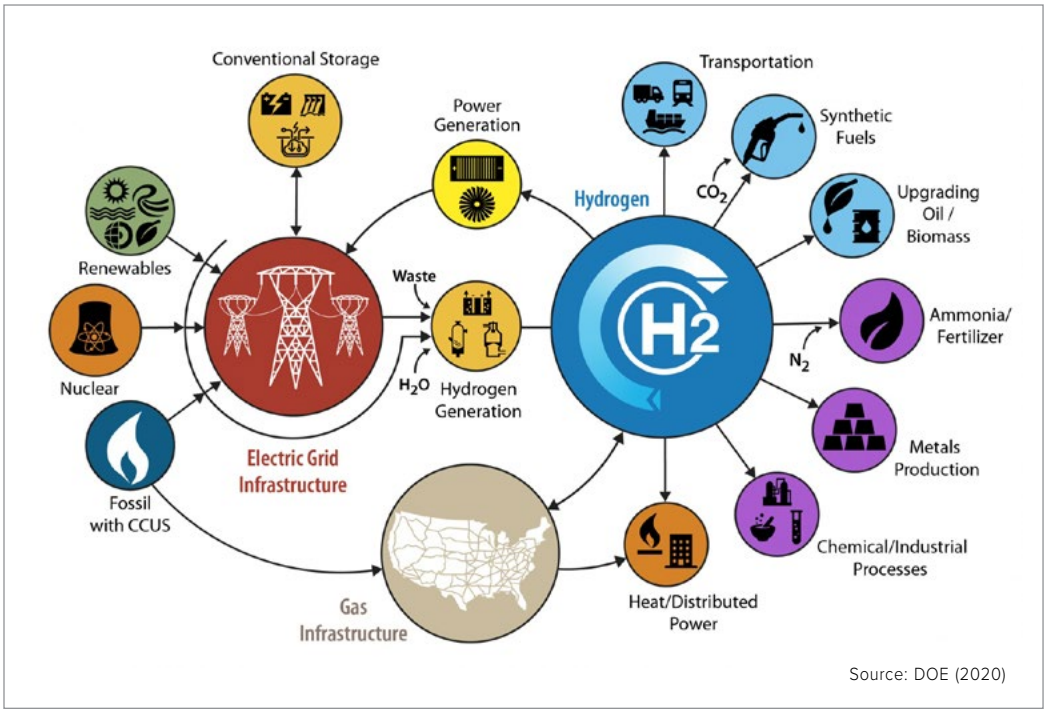
Bureau of Economic Geology Researcher Invited to Speak at Department of Energy's Energy Earthshot Kickoff

Bureau of Economic Geology researcher **Ian Duncan** was invited to be one of a handful of academic experts to present at the kickoff symposium for the Hydrogen Shot. The Hydrogen Shot initiative seeks to reduce the cost of clean hydrogen by 80 percent to $1 per kilogram in one decade. The Department of Energy's overall plan is to accelerate the development of "abundant, affordable, and reliable clean energy solutions within the decade." Achieving this will help reach the United States' goal of net-zero carbon emissions by 2050.

Ian Duncan

Duncan's research is part of the State of Texas Advanced Resource Recovery (STARR) program's work in support of understanding the possible mitigation of the coming energy transition's effect on the Texas economy. Duncan noted, "approximately half the oil in reservoirs in the US remains in the ground and most will never be produced using current technologies and prices." The STARR program is developing a method to utilize these resources to produce hydrogen that would enable the extraction of decarbonized energy from a source that otherwise would remain unused. This approach would combine an innovative implementation of the established in situ combustion technology with carbon dioxide (CO_2) sequestration.

"Our aim," according to Duncan, "is to produce relatively cheap hydrogen while sequestering CO_2 elsewhere in the reservoir complex." He also pointed out "Texas is well-positioned to take advantage of subsurface hydrogen production as it has huge resources of oil (much of it unlikely to be produced), a well-developed oil field infrastructure, and an extensive network of pipelines and rights-of-way."



Source: DOE (2020)

Bureau Research Featured in Smithsonian Magazine's Top Ten Dinosaur Discoveries

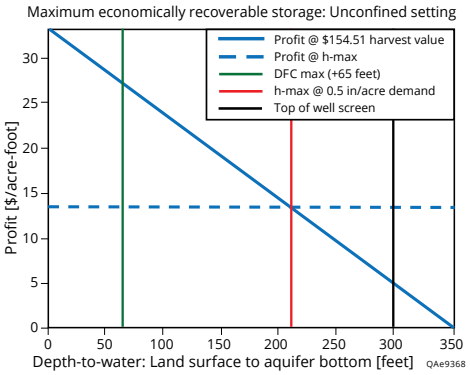
For years, scientists debated whether dinosaurs stayed in polar environments or migrated into warmer regions during the winter. Researchers have now found that dinosaurs, despite being cold-blooded creatures, remained in polar habitats year-round. Using a rare find of remains from a dromaeosaurid, Bureau Research Scientist **Peter Flaig** and colleagues found that these raptor-like dinosaurs overwintered and nested in polar regions. The research was published in PLOS ONE and featured in Smithsonian Magazine's article, "The Top Ten Dinosaur Discoveries of 2020," highlighting the importance of this discovery. The discovery was made possible by the finding of an uncommon fossil: a dromaeosaurid jawbone. Previous fossil evidence of this dinosaur has been limited to detached teeth. These are also the first nontooth remains of this dinosaur family found in the Arctic. The jawbone gave researchers substantial clues to the environment of these ancient animals. A variety of existing evidence—including study of the structure, chemistry, and movements of the bones—demonstrates that these dinosaurs had the necessary adaptation to survive harsh winters in the Arctic and would not have needed to migrate to warmer latitudes.

Peter Flaig

The polar findings are corroborated by research from other authors, including the discovery that polar dinosaurs slowed their growth during the winter, and that a newly discovered species lived exclusively in colder habitats.

Exploring Groundwater Recoverability in Texas

In 2017, the Texas state water plan projected a total water supply deficit of 4.8 million acre-feet under drought-of-record conditions by 2020 and a deficit of 8.9 million acre-feet by 2070. These deficits are driven by a growing demand for water (in turn driven by a growing population) concurrent with declining available water supplies. Reductions in groundwater supply account for 95 percent of anticipated declines in total water supply, illustrating the importance of management approaches. Some analyses have argued that restrictive groundwater management plans may be creating a regulation-induced shortage of groundwater in Texas. However, the state's yield estimates supporting these critiques do not account for many of the physical and none of the economic constraints to groundwater recoverability.

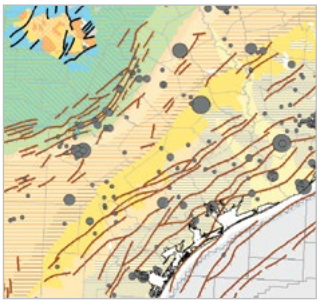


Jackson School Ph.D. student Justin Thompson, his adviser Michael Young, and former Bureau researcher Charlie Kreitler have developed a new framework for quantifying the feasibility of groundwater extraction using aquifer properties, pumping well characteristics, and economic constraints that identify sustainable groundwater withdrawal rates. The framework was tested for an agricultural case on the central section of the Carrizo–Wilcox Aquifer. The framework is capable of identifying the maximum capacity of the well and aquifer to meet demand and the point at which groundwater extraction costs exceed the economic activity. This new framework could provide groundwater conservation districts with a more holistic approach for assessing groundwater recoverability for its stakeholders. As Texas moves into the mid-21st century with higher water demand and uncertainty in terms of climate and groundwater recharge, improved water resource data will enhance the efficacy of water planning and management.

GCCC Holds Open House and Biannual Sponsor Meeting

The Gulf Coast Carbon Center (GCCC) held an open house for those interested in carbon capture and storage. The aim of the meeting was to provide technical expertise in reservoir characterization, CO_2 injection, CO_2 saturation, plume modelling, and environmental monitoring. Twelve speakers gave presentations with 83 attendees joining from 30 organizations.

The agenda followed the Big Plan, a four-year aspirational guiding document that contains the research themes of the group: a carbon capture, utilization, and storage ecosystem that encourages researchers to engage with a wide variety of stakeholders, preparing for large-volume storage; real-world leakage assessment; enhanced oil recovery evaluation and economics; and life cycle monitoring to find out how much monitoring is actually needed for a project. The open house was followed by a private afternoon session for GCCC sponsors, which include Air Products, BHP, BP, Chevron, ExxonMobil, Shell, and Total.



New Database Featuring Northern Gulf of Mexico Reservoir Quality Now Available


Bob Loucks

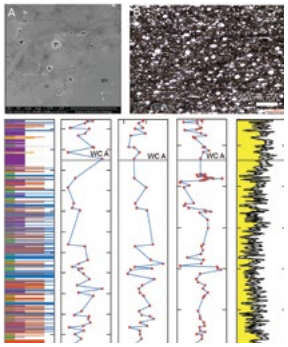

Shirley Dutton

The Bureau of Economic Geology's **Bob Loucks** and **Shirley Dutton** have compiled a comprehensive database for evaluating and forecasting reservoir quality (porosity and permeability), and for documenting mineralogy, grain size, and pore types, in the northern Gulf of Mexico onshore and offshore sandstones. These include Jurassic-, Cretaceous-, Tertiary-, and Pleistocene-aged reservoirs. This "GOMRQ" data set documenting reservoir-quality values provides extensive measurements from core (30,207 analyses from 646 wells), wireline-log (108,938 analyses from 53 wells), pool (summarized data from a reservoir; 12,658 pools), and mercury injection capillary pressure analyses (30 analyses), predominately from deep Wilcox cores. The petrographic thin-section database records detail point-count data of 889 thin sections from Jurassic- to Pliocene-aged sandstone from 148 wells. The data are provided in Excel spreadsheets with associated maps showing distribution of data regionally and stratigraphically.

Most of the point-counted thin sections are available at the Bureau of Economic Geology for viewing and further analysis. The database can be licensed from the Bureau of Economic Geology for a onetime fee.

Mudrock Systems Research Laboratory Consortium Hosts Annual Meeting

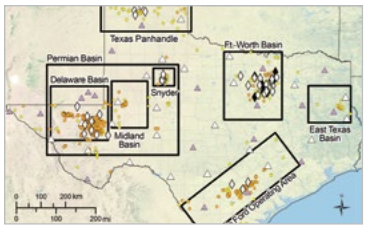
In April 2021, MSRL researchers hosted their annual technical meeting, which included four half-days of technical talks and a half-day short course titled "Fundamentals of Mudrock Systems." Over the course of the virtual meeting, over 110 industry scientists from 19 companies attended. In addition to presentations from MSRL researchers, David Mohrig, Associate Dean of the Jackson School of Geosciences, presented a short course titled "Mudrock Depositional Processes and Deepwater Turbidites."



The technical program covered fluid flow modeling and experimental results, and reservoir architecture and attributes of the Eagle Ford Shale, Austin Chalk, Bone Spring Formation from the Delaware Basin, and Wolfcamp A and B from the Midland and Delaware Basins. New reservoir characterization studies of Wolfcamp "XY sands" and First Bone Spring Sand and Second Bone Spring Lime were presented. The short course that focused on the fundamentals of mudrock systems was one of four short courses the MSRL taught in 2021.

TexNet Named Authoritative Network for Texas by the U.S. Geological Survey

After a short 5 years of fast growth, from a standing start, the Bureau's TexNet earthquake monitoring network has just been named as the authoritative network for Texas by the U.S. Geological Survey and has been incorporated into the USGS ComCat online catalog.



Successful TORA Spring Meeting Covers Machine Learning, Changing Business Opportunities

The Bureau of Economic Geology's Tight Oil Resource Assessment (TORA) program held its spring meeting with over 100 virtual attendees, including sponsor organizations from the United States, China, Colombia, Canada, and France. The meeting comprised 17 technical presentations, including a topical deep dive into novel, geologic rule-based machine learning workflows applicable to geoscience data.

Presentations covered various aspects of geology, geophysics, petrophysics, reservoir engineering, economics, data analytics, and machine learning under broad conference themes of Data Quality, Basin Architecture, Integrated Workflows, and Changing Business Environment and New Opportunities. The meeting focused on the Permian Basin but also provided an update on the resource estimates and drilling maturity of all major U.S. tight oil and gas plays and new concepts and methods applicable to all such plays, including identification of subseismic faults, 3D seismic inversion and interpretation, formation evaluation (including impacts of water salinity), fluid typing, new automated production outlook tools, well inventory analysis, and the reliability of publicly available data.


Emery Goodman (center) with TotalEnergies' Alexandre Poulard (left) and Alex Perry (right).

In addition to presenting basin-scale maps and 3D geomodels, TORA researchers also discussed the past, present, and future of Permian Basin energy economics, including the analysis and drilling potential of remaining well inventory in various productivity–and estimated ultimate recovery–defined bins. Understanding the subsurface remains critically important, as it controls productivity along with completion intensity. The implications of growing environmental, social, and corporate governance requirements on operators were also discussed.

$GeoH_2$ Holds Introductory Meeting and Workshop

Hydrogen (H_2) has tremendous potential to be a transportable, storable fuel, and hydrogen-generation technologies are rapidly evolving. The Bureau of Economic Geology is excited to announce that it is taking the next important step toward expanding its ongoing research into the growing hydrogen economy.

Key researchers from the Bureau's Hydrogen Group shared their latest and planned research in the introductory meeting of the new $GeoH_2$ research consortium. Research topics explored during this inaugural meeting of $GeoH_2$ included hydrogen market/infrastructure and integrated value-chain research; geological storage of hydrogen; and in situ generation and novel concepts. The meeting also included broad discussion of plans for this new consortium and how it will collaborate with industry, government, and other partners.

The Bureau of Economic Geology's H_2 Working Group also conducted a virtual workshop. One hundred and seventy-six interested people representing 101 companies and other organizations from around the world participated in the workshop to learn about the new consortium from H_2 Working Group's 13 Bureau researchers and from three scientists from The University of Texas at Austin's Cockrell School of Engineering. The group set out the concept for the consortium that will conduct research to facilitate and advance the development of a hydrogen economy at scale. In addition to introducing the H_2 Working Group's world-class research capability and proven track record of high-value research and impact, the workshop provided an overview of specific research areas and approaches and solicited feedback from participants. As with all of the Bureau's existing research consortia, $GeoH_2$ will offer extensive benefits for its members.

First-Year Students Visit TexNet

The Bureau of Economic Geology's TexNet statewide earthquake monitoring program hosted 15 first-year students enrolled in the UT Jackson School of Geosciences' GEO 401 Physical Geology class. GEO 401 is a course primarily designed for environmental and geological science majors. David Mohrig, the school's associate dean for research, explained that the visit was part of an ongoing effort to provide these students with informative field experiences and to make this introductory course more interactive.

In 2015, Texas Legislature requested help from the Bureau to detect the location and origins of earthquakes in Texas, and, if possible, help to prevent earthquakes caused by human activity from occurring in the future. In 2017, the TexNet Seismic Monitoring Program began mapping earthquakes via a dynamic web page, the TexNet Earthquake Catalog. TexNet's efforts help to keep the public informed on earthquake activity and help to improve earthquake response efforts.

Alexandros Savvaidis, manager of the TexNet program, welcomed the group and provided a broad overview of seismicity in Texas, the genesis and evolution of TexNet's extensive seismometer network, and its skilled, multidisciplinary team. TexNet research scientist associate Tricia Martone also provided the class with a report on the improvement over time in TexNet's ability to more precisely determine earthquake location.


Alexandros Savvaidis (standing).

The diverse group of freshman left the Bureau with a much better understanding of the recent earthquake activity in the state and TexNet's work to find the causes of these seismic events and to mitigate their impact—an important study for potential future environmental scientists and geoscientists.

Virtual Reality Technology:
Now an Affordable Tool for Geoscientists


Robin Dommisse

For many of us, virtual reality (VR) is a relatively expensive new technology utilized to enhance the video game experience. But for the Bureau of Economic Geology's **Robin Dommisse**, VR is a not-so-new and not-so-expensive technology that offers geoscientists incredible options to enrich their ability to visualize the nuances of rock formations.


Charles Kerans

To see a presentation by Robin Dommisse about the latest geological adaptations of VR technology, featuring Bureau outcrop studies from Senior Research Scientist **Charles Kerans** and Ph.D. candidate Buddy Price, please go to the Bureau's YouTube channel, https://www.youtube.com/c/BureauofEconomicGeology.


"Recent advances in virtual reality headset technology and software have made it easier and more affordable than ever before to capture...geology in 3D," explains Dommisse, "it enables us to better study rock outcrops using computers."

GeoGulf2021 Showcases Latest Geoscience Research

GeoGulf2021 in action. (Left to right) Toti Larson, Mark Shuster, Katrin Ruckwied, Scott Tinker, Kelly Hattori, Bob Loucks, and Dallas Dunlap.

Hosted in Austin by the Bureau of Economic Geology and the Austin Geological Society, the recent GeoGulf2021, the 71st Annual Gulf Coast Geoscience Convention, successfully brought together over 350 students, industry professionals, researchers, and faculty for a week of interaction and high-quality technical presentations. It was the first major in person geosciences conference held in Central Texas since the onset of the pandemic and provided for streaming participation for those unable to travel. The theme for GeoGulf2021 was "Sustaining Geoscience Through the Energy Transition," and the conference included topics ranging from oil and gas resources to emerging and new approaches to resources and technologies.

The Bureau led multiple topic sessions, and thirty-one Bureau researchers and staff participated in the conference as speakers, presenters, and hosts. GeoGulf2021 included 17 oral technical presentations and related poster sessions covering geoscience themes relevant to Gulf Coast geology, energy resources, water resources, geohazards, and technology applications. Participants also enjoyed expert panel sessions on shale plays, diversity, careers, and the regulatory landscape. Additionally, they were able to take part in five virtual and live field trips and four short courses.

Bureau of Economic Geology contributions to GeoGulf2021 were extensive, and those who attended were highly complimentary of the quality and breadth of the program and related activities.

Texas Geologic Mapping Committee 2021 Annual Meeting Held at the Bureau

Representatives from six Texas state agencies (Texas General Land Office, Railroad Commission of Texas, Texas Water Development Board, Texas Commission on Environmental Quality, Texas Parks and Wildlife Department, and Texas Natural Resources Information System) convened at the Bureau on November 15, 2021, to discuss geologic mapping priorities in Texas.

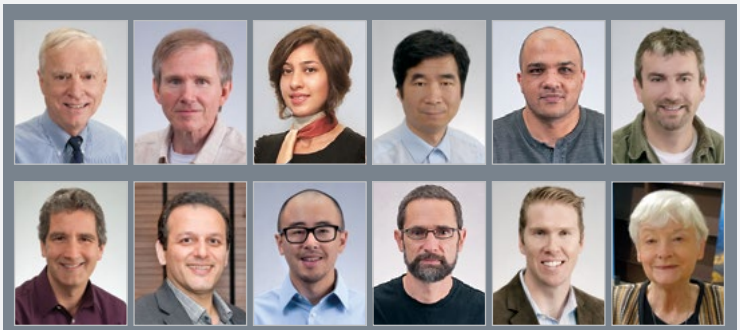
After lively discussion, short- (one year) and longer-term priorities were determined, including geologic mapping (1) on the Texas Coastal Plain to understand coastal-plain evolution and identify sand resources for coastal restoration, (2) in central and southwest Texas to support water- and mineral-resource evaluations, (3) in the Central Texas urban growth corridor to keep pace with rapid urbanization, and (4) in the Trans-Pecos to continue new work in that area related to critical minerals. Results from this meeting will help guide preparation of the FY2023 STATEMAP proposal, a cooperative federal and state program that is expanding with the advent of the U.S. GeoFramework Initiative to produce seamless and 3D-enabled geologic maps for the nation. We greatly appreciate the state agency representatives who assisted us in our prioritization efforts this year.

Jeff Paine (center) giving a lively discussion.

Honors

Bureau Researchers Honored at First Author Publications Awards Ceremony

Over 70 researchers and staff joined the formal Zoom ceremony honoring authors of 2020 publications, hosted by Director **Scott W. Tinker**. Bureau authors reported 140 publications for 2020. Among the researchers whose papers were published, seven were first-time first authors last year. **Bob Loucks** and **Bill Ambrose** tied for the lead for most times honored at the event (13), and **Sahar Bakhshian**, **Qilong Fu**, and **Ashraf Rateb** tied for most first-authored papers in 2020 with three each. **Sergey Fomel** had the most student first-authored papers in 2020 with seven.



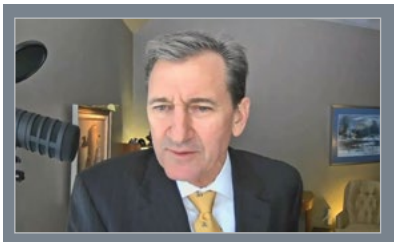
(Left to right) Robert Loucks, William Ambrose, Sahar Bakhshian, Qilong Fu, Ashraf Rateb, Tim Dooley, Mike Hudec, Seyyed Hosseini, Jinyu Zhang, Zoltán Sylvester, Jake Covault, and Amanda Masterson.

This year there was a tie for runner-up for the 2021 Tinker Family BEG Publication Award. The first runners-up were **Tim Dooley** and **Mike Hudec** for "Extension and Inversion of Salt-Bearing Rift Systems," published in Solid Earth. Their paper was tied with two papers. **Sahar Bakhshian, Seyyed Hosseini,** and their coauthors wrote "Scaling of Imbibition Front Dynamics in Heterogeneous Porous Media," published in Geophysical Research Letters; and Bakhshian, Hosseini, and coauthors also wrote "New Insights into Complex Interactions between Heterogeneity and Wettability Influencing Two-Phase Flow in Porous Media," also published in Geophysical Research Letters.

The winners of the 2021 Tinker Family BEG Publication Award, presented for "advancing the scientific understanding of controls on sedimentary basin filling using novel computational approaches," were **Jinyu Zhang**, **Zoltán Sylvester**, and **Jake Covault** for their important journal article, "How do Basin Margins Record Long-Term Tectonic and Climatic Changes?" published in Geology.

During the ceremony, a Special Recognition Award was presented to the Bureau's **Amanda Masterson** in appreciation of her many years of service on its Editorial Board, and a Special Recognition Award was also presented posthumously to the family of **Steve Ruppel** "in recognition of career contributions to the understanding of the geologic evolution of the Permian Basin."

Bureau Director Testifies Before U.S. Senate Committee on Energy and Natural Resources



Scott W. Tinker

Bureau of Economic Geology Director **Scott W. Tinker** testified before the U.S. Senate Committee on Energy and Natural Resources on February 3, 2021. Chaired by Senator Joe Manchin of West Virginia, the Committee convened in its first meeting of the new Congress to "draw on data and analysis by the United States' and world's leading authorities on global climate trends from energy related sectors to consider where and how progress has been made in addressing climate change."

Director Tinker was invited to testify along with Dr. Fatih Birol, Executive Director, International Energy Agency; Mr. Mark Mills, Senior Fellow, The Manhattan Institute; Dr. Angel Hsu, Assistant Professor, University of North Carolina–Chappell Hill; and Dr. Richard Newell, President and CEO, Resources for the Future.

Scott Tinker opened his testimony by stating, "We all share a common desire to provide affordable and reliable energy in order to grow healthy economies and lift the world from poverty, while also minimizing environmental impacts, including climate, land, water, and air." He then laid out the challenges and opportunities inherent in reaching that objective, and how the United States could support activities inherent in achieving this strategic goal.

2021 Society of Petroleum Engineers Southwestern Region Young Member Outstanding Service Award

Bureau Research Associate and reservoir engineer **Bo Ren** was awarded the 2021 Society of Petroleum Engineers Southwestern Region Young Member Outstanding Service Award. Bo is an improved low-carbon energy recovery engineer working for the State of Texas Advanced Resource Recovery (STARR) program. His research interests include CO_2-enhanced oil recovery, hydrogen, geological carbon sequestration, and reservoir optimization and management.

The University of Texas at Austin's 2021 Outstanding Staff Award

Longtime Bureau of Economic Geology IT specialist **Joseph Yeh** was recognized with two important awards. He was nominated by Bureau colleagues to be one of only 30 recipients of The University of Texas at Austin President's 2021 Outstanding Staff Award. Joseph has worked tirelessly since the initial evacuation of Bureau facilities last year at the start of COVID-19 safety precautions to ensure that researchers and staff have the equipment and the technical ability to work remotely. He was also honored by the Bureau of Economic Geology with its 2020 Bureau Staff Excellence Award for his vital role in successfully transitioning the Bureau to an entirely different way of conducting daily operations.

Energy Leadership Award

Bureau Director **Scott W. Tinker** was recognized by Hart Energy as the recipient of its special Energy Leadership Award. He is being recognized "for his influential writing, speaking, and documentary production and appearances, which advance understanding of resource development and the world's energy needs."

Other significant honors were bestowed upon Bureau of Economic Geology researchers in 2021 in recognition of their broad accomplishments. Among those were:

Kitty Milliken was granted Honorary Membership in the Society for Sedimentary Geology (SEPM)

Charles Kerans received the Lifetime Membership Award from the West Texas Geological Society

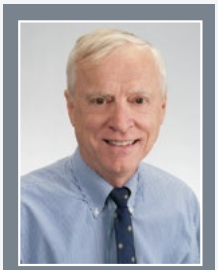
Farzam Javadpour and coauthors were included in Energy & Fuels' Top 25 Most Cited Articles in 2018 for their paper, "Supercritical Methane Diffusion in Shale Nanopores: Effects of Pressure, Mineral Types, and Moisture Content"

Alexander Sun was selected to receive the 2020 Editors' Citation for Excellence in Refereeing for Geophysical Research Letters by American Geophysical Union (AGU) Publications

2021 GCAGS Transactions Volume Dedicated to Robert G. Loucks

One would be hard-pressed to list a more energetic senior research scientist in the history of the Bureau of Economic Geology, or one with a broader range of publications, leadership service, and individual accolades, than **Robert G. Loucks**. At the recent GeoGulf2021 conference, Bob Loucks added yet another significant tribute to his work and reputation when it was announced that the 2021 Gulf Coast Association of Geological Societies (GCAGS) Transactions Volume would be dedicated to him by the Austin Geological Society and GCAGS "in recognition of his exceptional contributions to carbonate geology and the Gulf Coast geological community."

Bob Loucks' research has covered a range of geologic subdisciplines over the years, including carbonate deposition and diagenesis, carbonate stratigraphy and sedimentology, sandstone stratigraphy and diagenesis, mudrock geology, pore characterization, karst processes and paleocaves. His service record shows a long history of leadership and advisory contributions, and he has served as a mentor and adviser to dozens of students throughout his career. A prolific author, Dr. Loucks has received the GCAGS Journal Best Paper Award three times, the A. I. Levorsen Award for best paper at GCSSEPM and WTGS twice, and the Wallace E. Pratt Award for best AAPG Bulletin Paper. Additionally, among his honors are the AAPG Bob Berg Outstanding Research Award and the Karst Water Institute Research Award.



Robert Loucks

Outreach

Water Resources and Innovative Water Strategies Virtual Field Trip

Bureau staff **Linda Ruiz McCall**, **Charles (Chock) M. Woodruff Jr.**, **Brian B. Hunt**, **Aaron Averett**, and **Bridget Scanlon** created a virtual field trip entitled "Water Resourced and Innovative Water Strategies in Central Texas." Field sites for the trip include visits to Mount Bonnell, Tom Miller Dam, Barton Springs Pool, Jacob's Well, and recharge features along Onion Creek and the Blanco River, as well as the Ruby Ranch Water Supply Corporation aquifer storage and recovery site.

Originally, the virtual field trip was created for the GeoGulf2021 conference and is now available at **https://www.beg.utexas.edu/outreach/educational-resources**.

Chock Woodruff at the Mount Bonnell field site posted on https://youtu.be/UtARsaoJ99k.

Chock Woodruff (shown above) explains how the Balcones Fault Zone and the erosion over time caused by the Colorado River sculpted the terrain to form the Balcones Escarpment.

Brian Hunt (shown to the left) explains how scientists carefully monitor the flow and water quality of the water, which is the lowest discharge point for the Edwards Aquifer in the region.

Brian Hunt at the Barton Springs field site posted on https://youtu.be/AaOkACJql38.

Texas Environmental Educators and Texas Education Agency Annual Meeting

On January 8, 2021, the Bureau of Economic Geology hosted the **Texas Environmental Education Advisory Committee (TEEAC)** Annual Providers' meeting. The meeting was organized by **Linda Ruiz McCall**, the Bureau Information Geologist and Resource Center Manager, Kiki Corry of Texas Parks and Wildlife and TEEAC chair, and Irene Pickhardt, Statewide Science Coordinator, Curriculum Division of the TEA. Due to the pandemic, the meeting was held on Zoom. Bureau staff member **Aaron Averett** provided technical support and video editing.

TEEAC Providers assist the Texas Education Agency (TEA) by offering workshops for teachers and experiences for students that are correlated with the Texas Essential Knowledge and Skills (TEKS) standards; these workshops include hands-on laboratory and field experiences. The meeting included 130 TEEAC Providers from museums, universities, state agencies, zoos, and nature centers from across Texas. The attendees left with useful information and a network of contacts to use in their future work.

In May of 2021, a **Texas GeoSign** created by the Bureau of Economic Geology in cooperation with the city of Austin was installed at Mount Bonnell in Austin, Texas. The mission of the Texas GeoSign program is to enhance the public understanding and appreciation for the geology and geologic history of Texas. **Linda Ruiz McCall**, **Chock Woodruff**, and **Francine Mastrangelo** seen in the photo (left) lead the work on the Mount Bonnell sign. **Ramón A. Gil Egui** and **Ramón Treviño** translated the Mount Bonnell sign into Spanish. In addition to the physical signs, the Bureau has established a **website** where the signs and other information may be viewed and downloaded.

EarthDate: An Amazing and Powerful Tool for Educators

EarthDate is a vibrant, entertaining, and educational weekly radio program now reaching thousands of listeners on 429 radio stations in all 50 states and Canada. There are now 270 educational podcasts ready for download and playback from the **Bureau's website**.

Bureau Director and Texas State Geologist **Scott Tinker** hosts each two-minute episode. "We launched *EarthDate* in 2017 as a public service radio program with a mission to engage listeners in stories about Earth and to reconnect them to the wonders of their world," recalled Director Tinker. "*EarthDate* reminds listeners that science can enlighten, educate, and entertain."

New Mineral, Rock, and Fossil Exhibit

A **Mineral, Rock, and Fossil Gallery** is now open at the Bureau of Economic Geology. The collection showcases specimens from Texas as well as localities around the world. The project was spearheaded by **Linda Ruiz McCall** and **Jay Kipper** with assistance from **Francine Mastrangelo**, Lisa Boucher, Matthew Brown, John Maisano, **Nathan Ivicic**, **Brandon Williamson**, and **Rudy Lucero**. The image to the right is a cast of a dimetrodon that was donated by retired Bureau geologist **Tucker Hentz**.

Explore UT

Due to the pandemic, the **2021 Explore UT** event was held virtually. The Bureau contributed many of the web resources, including ***EarthDate***, ***Switch***, ***Switch On***, **Switch Energy Labs**, and **Austin Earth Science Zoomerama** presentations, which were hosted by UT researchers.

GeoFORCE TEXAS
JACKSON SCHOOL OF GEOSCIENCES


Tristan Childress

Bureau geologist **Tristan Childress** served as the instructor for **GeoFORCE** Virtual 9th Grade (GFV9) Academy, which included learning topics such as Texas rivers, the Gulf of Mexico, hydrocarbon seeps, coral reefs, and ancient fossil reefs as seen in the Guadalupe Mountains. The session included a Career Spotlight where a wide diversity of industry speakers spoke about their careers and answered questions from students, including one previous GeoFORCE student who is now an exploration geologist.

Research Consortia

Research Partnerships *with the Bureau of Economic Geology*

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 broad spectrum of which actively participate in its 12 research consortia. Each consortium was designed to complement partner efforts to explain a key exploration, production, environmental, and/or economic problem. 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, creating combined teams of seasoned experts and early career specialists. Experienced and effective principal investigators lead each consortium.

Contact the PI of any program of interest to you. For further information about these research consortia, and the breadth of your organization's engagement with the Bureau, please contact us at www.beg.utexas.edu or by phone at 512-471-1534. Download the consortia brochure: https://www.beg.utexas.edu/about/reports-and-information.

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 2021. 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 Advanced Energy Consortium 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.

Contact:

Dr. Mohsen Ahmadian
mohsen.ahmadian@beg.utexas.edu, (U.S.) 512-471-2999

David Chapman
david.chapman@beg.utexas.edu, (U.S.) 512-475-9563
https://www.beg.utexas.edu/aec

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 datasets, 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; 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.

Contact:

Dr. Michael R. Hudec
michael.hudec@beg.utexas.edu, (U.S.) 512-471-1428
https://www.beg.utexas.edu/agl

Comparing Electricity Options

Mission

The mission of the Comparing Electricity Options (CEO) research consortium is to conduct a science- and data-driven life cycle analysis (LCA) of local and global environmental impacts, including greenhouse gas and local emissions, land and water pollution and use, biodiversity and ecosystem services, associated with supply chains and the life cycle of our main electricity generation options. By comparing these life cycle impacts, CEO can assess and highlight the 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 the population.

Research Thrusts

The goals of the CEO consortium are to create tools that support energy sector decision and policy makers with their overall economic and environmental assessments to manage supply chain and environmental, social, and governance risks, based on current and projected commodity demands; highlight where innovation can add value to their available options; and inform policies that drive measurable improvement and encourage optimal innovation and adoption.

Research Challenges

The field of life cycle analysis research relies on in-depth understanding of the various activities along the supply chain for respective technologies. Publicly available data on these global activities are often scarce or focus on specific impacts, and many US-based mining and related projects are either proposed or still in development. Trusted information is difficult to find. Connecting with supply chain stakeholders and accessing primary data is key to developing realistic and holistic LCAs.

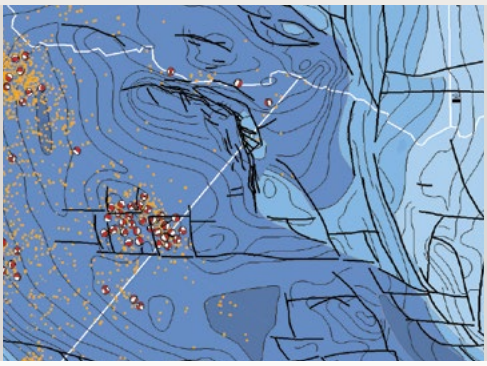
Membership

CEO is currently funded by five industrial affiliates and growing. Membership is tiered to accommodate all interested partners.

Contact:

Dr. Michael Young
michael.young@beg.utexas.edu, (U.S.) 512-475-8830
Dr. Tristan M. Childress
tristan.childress@beg.utexas.edu, (U.S.) 512-471-1812
https://www.beg.utexas.edu/ceo

Center for Integrated Seismicity Research



Mission

The Center for Integrated Seismicity Research (CISR) is a multi-disciplinary, intercollegiate research consortium managed by the Bureau. TexNet and CISR are two parts of a whole; the former is the state funded network of seismometers across Texas that monitors and catalogs earthquakes and conducts research into aspects of causation in key areas. With its industry partners, 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 improves standards of practice for mitigation.

Research Thrusts

CISR conducts fundamental and applied research to better explain seismicity of all causes and its associated hazards. CISR relies on research specialists from the Bureau, the Department of Geologic Sciences, the Institute for Geophysics, and the Department of Petroleum and Geosystems Engineering at UT. We also partner with Southern Methodist University, UT EL Paso, Stanford University, and consulting specialists.

Research Challenges

Over the past decade, the rate of seismicity in the South Central United States has increased markedly, especially in unconventional play areas where water management and sustainable development are increasingly important challenges. Understanding the interplay between complex operational drivers 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 are CISR members. Each company has one member who serves on the CISR Advisory Committee, which meets quarterly to discuss the design and application of TexNet–CISR research. Member companies are encouraged to assist with identification of land parcels that can be used for seismic monitoring and 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.

Contact:

Dr. Peter Hennings
peter.hennings@beg.utexas.edu, (U.S.) 512-471-0156
https://www.beg.utexas.edu/texnet-cisr

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 challenges to exploration and development. Our approach is helping to overcome the limitations of current methods.

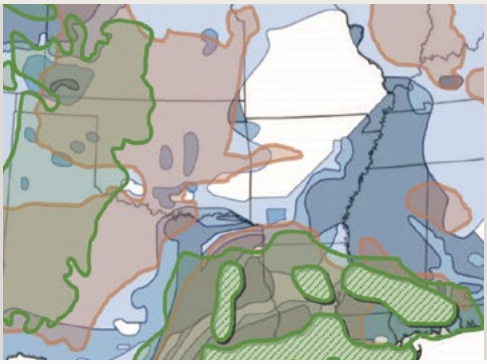
Membership

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.

Contact:

Dr. Stephen E. Laubach
steve.laubach@beg.utexas.edu, (U.S.) 512-471-6303
Dr. Julia F. W. Gale
julia.gale@beg.utexas.edu, (U.S.) 512-232-7957
Dr. Jon E. Olson
jolson@austin.utexas.edu, (U.S.) 512-471-7375
https://www.beg.utexas.edu/frac
https://www.jsg.utexas.edu/sdi/

GeoH$_2$



Mission

GeoH$_2$, a new research consortium, will conduct geoscience and economic research to facilitate and advance the development of a hydrogen economy *at scale*. GeoH$_2$ 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 underground porous reservoirs under a wide range of reservoir conditions to inform economic suitability analyses for different reservoir types and fields in different energy markets. Research will also be conducted on generating hydrogen in the subsurface by in situ combustion of hydrocarbons. Techno-economic analyses evaluate the feasibility of storage technologies and operational parameters for a range of anticipated market conditions and regulatory frameworks.

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.

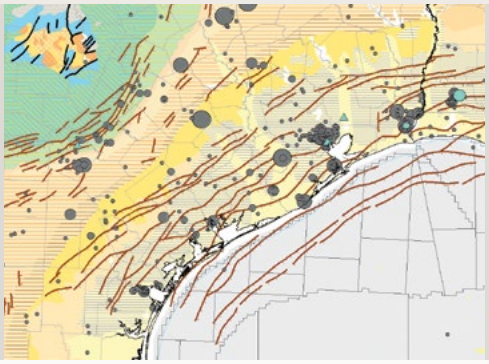
Membership

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.

Contact:

Dr. Mark Shuster
mark.shuster@beg.utexas.edu, (U.S.) 512-471-7090
Dr. Peter Eichhubl
peter.eichhubl@beg.utexas.edu, (U.S.) 512-475-8829
https://www.beg.utexas.edu/geoh2

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_2). Carbon dioxide can be captured from high concentration emissions from industrial facilities or low concentrations from the atmosphere and then injected for permanent storage in porous rocks kilometers below and isolated from the surface.

Research Thrusts

GCCC research into large-volume CO_2 storage (1) improves structural and stratigraphic characterization methods and simulation approaches to identify suitable storage locations; (2) creates workflows for characterization at pore to basin scales that prepare multiple sites to be operated at maximum injection rates and over prolonged time periods; (3) assesses storage resources in offshore subsea settings in the Gulf of Mexico and globally and (4) develops and tests monitoring approaches to meet regulatory and social license to operate demands. Monitoring developed for CO_2–enhanced oil recovery (EOR) assess the intersection of economic value with storage value with life cycle considerations.

Research Challenges

Carbon capture and storage (CCS) deployment is not happening at the rate and scale needed to achieve emissions reduction goals. Many influential stakeholders, from industrial investors to policymakers to journalists, do not have the information needed to see the critical role of CCS in attaining these goals and the viability of CCS.

Membership

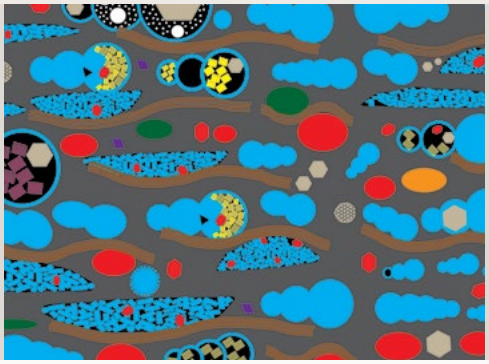
Members meet twice a year, sometimes jointly with other related groups, and receive a quarterly newsletter.

Contact:

Dr. Susan D. Hovorka
susan.hovorka@beg.utexas.edu, (U.S.) 512-471-4863

Dr. Tip Meckel
tip.meckel@beg.utexas.edu, (U.S.) 512-471-4306
https://www.beg.utexas.edu/gccc

Mudrock Systems Research Laboratory



Mission

The Bureau's Mudrock Systems Research Laboratory (MSRL) program brings together a broad spectrum of research expertise necessary to confront the complicated, multidisciplinary questions key to a better understanding of mudrock systems. The goal of the program is to integrate observations and data from all scales, ranging from nanoscale to basin scale. Only through this kind of integrated analysis can the multiscalar heterogeneities of mudrocks be effectively characterized and models leading to better predictions of reservoir quality be developed.

Research Thrusts

MSRL research activities include the following: field emission scanning electron microscope study of pore architecture, grain types, and diagenesis; analysis of mechanical properties; application of X-ray fluorescence and isotope geochemistry to better define facies and their continuity; delineation and modeling of regional and local trends in depositional and diagenetic facies distribution; development of more-accurate ways to determine porosity, permeability, and flow; critical appraisal of conventional methods of mudrock-analysis techniques; and core-based calibration of borehole geophysical logs for facies mapping.

Research Challenges

Despite their abundance in Earth's crust, mudrocks are not as well understood as other reservoir systems. The current explosion of interest in a better understanding of these rocks stems from the need to devise more-efficient ways of extracting oil and gas from these reservoirs. Our challenge is to develop new methodologies for characterizing these rocks and the fluids they contain. We are meeting this challenge by carrying out integrated studies of rock and fluid attributes on high-precision, high-resolution instruments operated by MSRL researchers.

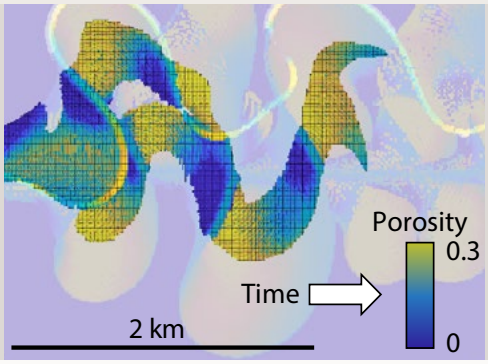
Membership

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

Contact:

Dr. Toti Larson
toti.larson@beg.utexas.edu, (U.S.) 512-471-1856
https://www.beg.utexas.edu/msrl

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 datasets 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.

Contact:

Dr. Jacob (Jake) Covault
jake.covault@beg.utexas.edu, (U.S.) 512-475-9506
Dr. Zoltán Sylvester
zoltan.sylvester@beg.utexas.edu, (U.S.) 512-475-9514
https://www.beg.utexas.edu/qcl

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. In addition, the RCRL is dedicated to technology transfer and education and consistently offers state-of-the-art training, such as short courses, field seminars, in-company reviews of assets, and extensive student supervision and guided research.

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.

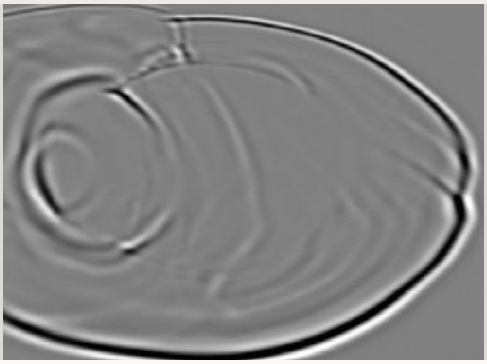
Membership

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.

Contact:

Dr. Xavier Janson
xavier.janson@beg.utexas.edu, (U.S.) 512-475-9524
Dr. Christopher (Chris) Zahm
chris.zahm@beg.utexas.edu, (U.S.) 512-471-3159
https://www.beg.utexas.edu/rcrl

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 research areas include the following: high-resolution imaging of the Barrolka dataset using diffraction attributes; characterization of fractured shale reservoirs using anelliptic parameters; phase correction of prestack seismic data using local attributes; extraction of seismic events by predictive painting and time warping; low-rank, reverse time migration for subsalt imaging; high-resolution seismic attributes for fracture characterization in the Grosmont Formation; waveform tomography with cost function in the image domain; multi-azimuth seismic diffraction imaging for fracture characterization in low-permeability gas formations; and seismic-wave focusing for subsurface imaging and enhanced oil recovery.

Research Challenges

TCCS is a collaboration between the Bureau and the UT Oden Institute for Computational Engineering and Sciences, which is involved in estimating seismic velocities by using full waveform information, identifying the most accurate and efficient seismic imaging algorithms while controlling the trade-off between accuracy and efficiency, increasing the resolution of seismic reservoir characterization, and assisting the seismic interpreter by automating common interpretation and signal-processing tasks.

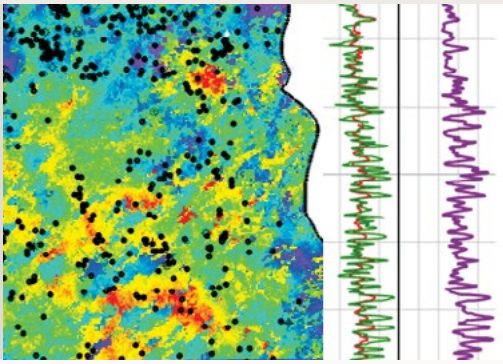
Membership

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.

Contact:

Dr. Sergey Fomel
sergey.fomel@beg.utexas.edu, (U.S.) 512-475-9573
https://www.beg.utexas.edu/tccs

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/shale gas (TO/SG) plays by conducting innovative, integrated research of in-place resources and recoverable volumes, play/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 1-mi^2 scale.

Membership

TORA membership is $50,000 annually as of January 2022.

Contact:

Dr. Emery Goodman, Principal Investigator
emery.goodman@beg.utexas.edu, (U.S.) 281-546-3047
https://www.beg.utexas.edu/tora

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 is now available through the interactive TexNet Earthquake Catalog at **catalog.texnet.beg.utexas.edu**. Relocated high-resolution earthquake data is now available at **hirescatalog.texnet.beg.utexas.edu/**. Also, injection of produced water volume information is available at **injection.texnet.beg.utexas.edu/**.

Contact:
Dr. Alexandros Savvaidis
Principal Investigator—Seismology and TexNet Manager
alexandros.savvaidis@beg.utexas.edu
(U.S.) 512-475-9549
https://www.beg.utexas.edu/texnet-cisr/texnet

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_2 Enhanced Oil Recovery; and (3) conceptualizing and developing geological, geophysical, and engineering projects to support the energy transition in Texas.

Research Challenges

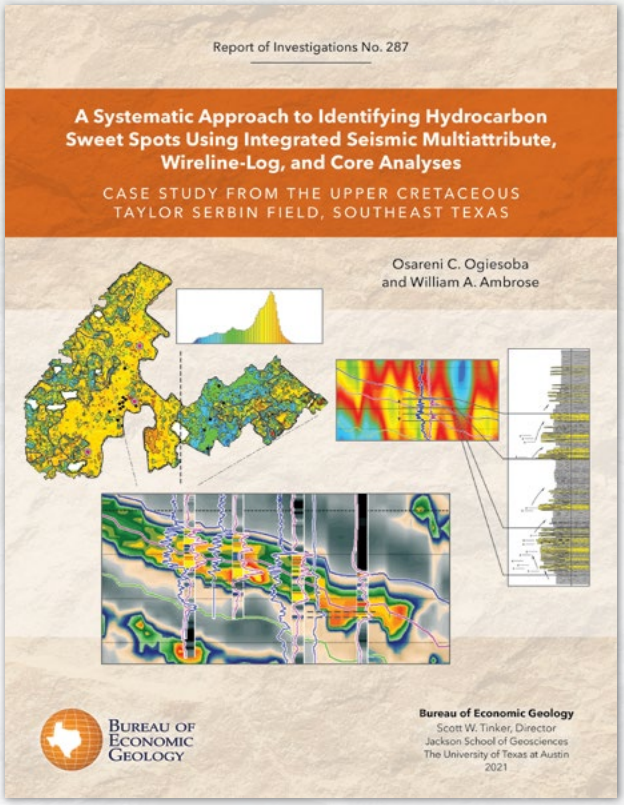
Challenges undertaken by the STARR team are wide and varied, ranging from explaining subsurface characteristics that control oil and gas production in Texas reservoirs to engineering challenges associated with identifying best enhanced recovery practices that have the potential for increasing oil and gas production in Texas oil fields. Recently, 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's 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.

Contact:
Dr. Lorena Moscardelli
Principal Investigator
lorena.moscardelli@beg.utexas.edu
(U.S.) 512-471-0258
https://www.beg.utexas.edu/research/programs/starr

Publications



A Systematic Approach to Identifying Hydrocarbon Sweet Spots Using Integrated Seismic Multiattribute, Wireline-Log, and Core Analyses:
Case Study from the Upper Cretaceous Taylor Serbin Field, Southeast Texas

Ogiesoba, O. C., and Ambrose, W. A., 2021, A systematic approach to identifying hydrocarbon sweet spots using integrated seismic multiattribute, wireline-log, and core analyses: case study from the Upper Cretaceous Taylor Serbin field, southeast Texas: The University of Texas at Austin, Bureau of Economic Geology Report of Investigations No. 287, 76 p., doi.org/10.23867/RI0287D.

This report discusses results of an investigation conducted to determine hydrocarbon sweet spots distribution within the Campanian Taylor sandstone in Serbin field, covering 56 mi² (~90 km²) and straddling parts of Lee, Bastrop, and Fayette Counties in southeast Texas. By integrating 3D-seismic-multiattribute analysis, neural network techniques, and core data, we demonstrate that (1) hydrocarbon sweet spots are laterally separated by mudstones and calcite- and quartz-cemented sandstones, (2) within the Taylor sandstones in Serbin field, porosity increases with depth, and (3) the Serbin field is separated into two areas: (i) a diagenetically altered, high-impedance, low-porosity rock area in the western section, and (ii) a low-impedance and relatively high-porosity sandstones area located in the eastern section.

STATEMAP

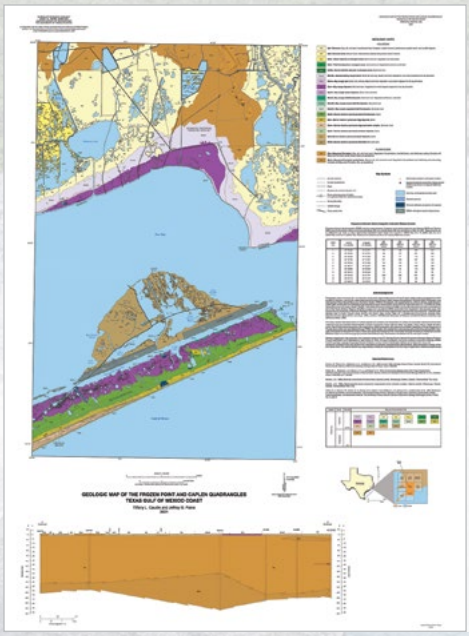
Bureau mapping efforts continue to expand in response to the new U.S. GeoFramework Initiative to prepare seamless, three-dimensional geologic maps and models of the United States. Bureau researchers, illustrators, and editors have produced seven new geologic maps and geodatabases for the most recent 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. Both organizations provide matches that equal the required federal support for the program. Thanks to the very effective matching money that the Bureau is able to put against federal funding, Texas has become a go to state for the STATEMAP program. This provides a fantastic return on investment of tax dollars and provides the basic science foundation for multiple industries.

Since STATEMAP began in the 1990s, geologic maps of 248 quadrangles have been published in the Bureau's Open-File Map series, along with several compilation maps in the peer-reviewed Miscellaneous Maps series. All maps are available through The Bureau Store.

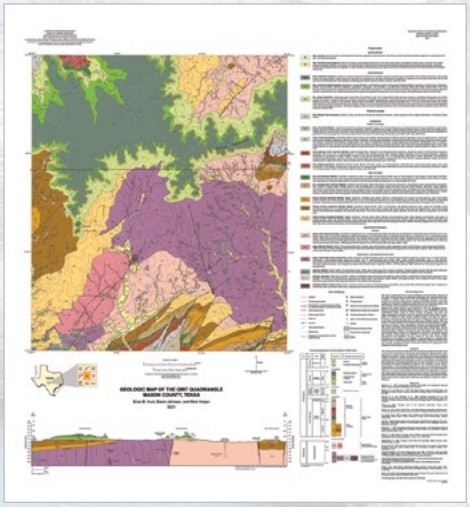
This year's new maps include the Frozen Point and Caplen quadrangles in the Galveston Bay area, the Palacios and Turtle Bay quadrangles in the Matagorda Bay area, and the Grit and Lytton Springs quadrangles in Central Texas. In addition, two 1:50,000-scale compilation maps were completed for the Pedernales Falls area in Central Texas and the Copano 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 (Grit) and on geologic units relevant to rapidly changing land-use patterns in the Central Texas urban growth corridor (Lytton Springs). Major contributors to the recent mapping effort include **Tiffany Caudle**, **Lucie Costard**, **Brian Hunt**, **Jeff Paine** (Principal Investigator), and **Chock Woodruff**. Bureau graphics and editing staff **Jana Robinson**, **Nancy Cottington**, **Francine Mastrangelo**, **Jason Suarez**, **Travis Hobbs**, and **Elyse Vane** prepared the maps for publication.

The Bureau Store
The official store of the Bureau of Economic Geology

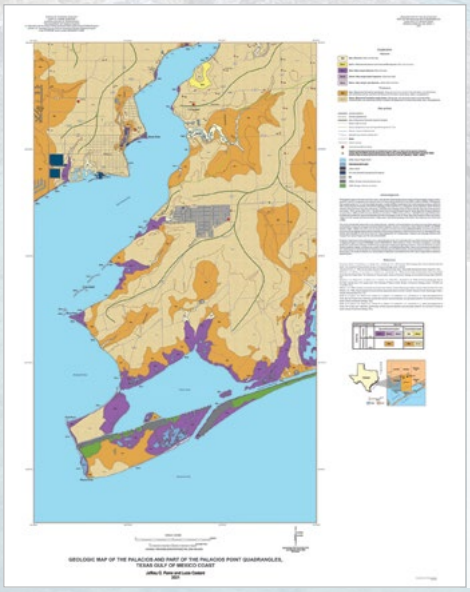
To purchase any of these publications, visit The Bureau Store: https://store.beg.utexas.edu/



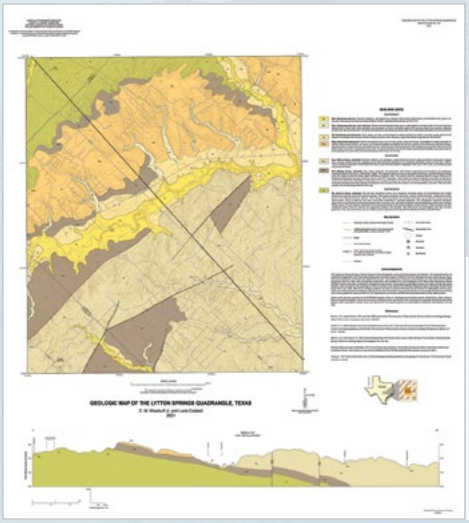
Geologic Map of the Frozen Point and Caplen Quadrangles Texas Gulf of Mexico Coast
Caudle, T.L., and Paine, J.G., 2021: The University of Texas at Austin, Bureau of Economic Geology Open-File Map No. 249, scale 1:24,000.



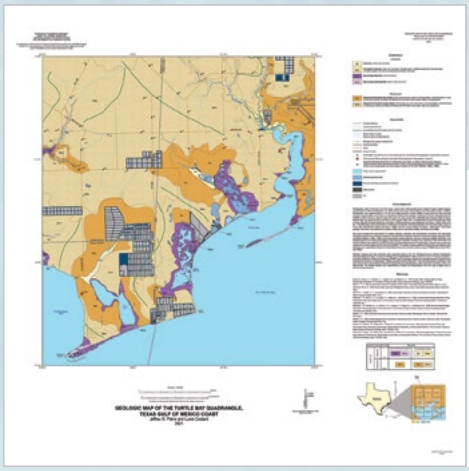
Geologic Map of the Grit Quadrangle Mason County, Texas
Hunt, B.B., Johnson, B., and Helper, M., 2021: The University of Texas at Austin, Bureau of Economic Geology Open-File Map No. 252, 2 sheets, scale 1:24,000.



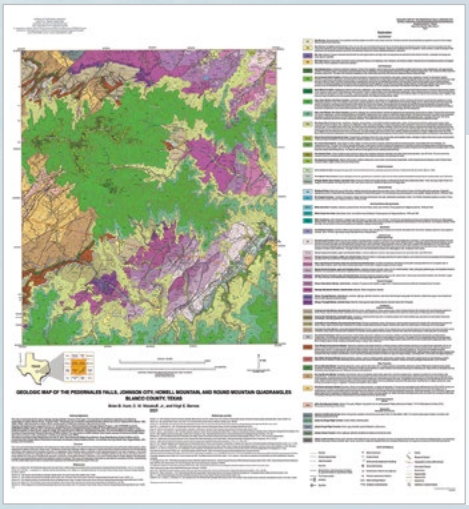
Geologic Map of the Palacios and Part of the Palacios Point Quadrangles, Texas Gulf of Mexico Coast
Paine, J.G., and Costard, L., 2021: The University of Texas at Austin, Bureau of Economic Geology Open-File Map No. 250, 2 sheets, scale 1:24,000.



Geologic Map of the Lytton Springs Quadrangle, Texas
Woodruff, Jr., C.M., and Costard, L., 2021: The University of Texas at Austin, Bureau of Economic Geology Open-File Map No. 253, scale 1:24,000.



Geologic Map of the Turtle Bay Quadrangle, Texas Gulf of Mexico Coast
Paine, J.G., and Costard, L., 2021: The University of Texas at Austin, Bureau of Economic Geology Open-File Map No. 251, 2 sheets, scale 1:24,000.



Geologic Map of the Pedernales Falls, Johnson City, Howell Mountain, and Round Mountain Quadrangles Blanco County, Texas
Hunt, B.B., Woodruff, Jr., C.M., and Barnes, V.E., 2021: The University of Texas at Austin, Bureau of Economic Geology Open-File Map No. 255, 2 sheets, scale 1:50,000.

Peer-Reviewed Publications by Bureau Researchers

Abdelaal, M., Zeidouni, M., and Duncan, I. J., 2021, Effects of injection well operation conditions on CO_2 storage capacity in deep saline aquifers: Greenhouse Gases: Science and Technology, v. 11, no. 4, p. 734–749, http://doi.org/10.1002/ghg.2076.

Alam, S., Gebremichael, M., Ban, Z., Scanlon, B. R., Senay, G., and Lettenmaier, D. P., 2021, Post-drought groundwater storage recovery in California's Central Valley: Water Resources Research, v. 57, no. e2021WR030352, 21 p., http://doi.org/10.1029/2021wr030352.

Bakhshian, S., 2021, Dynamics of dissolution trapping in geological carbon storage: International Journal of Greenhouse Gas Control, v. 112, no. 103520, 10 p., http://doi.org/10.1016/j.ijggc.2021.103520.

Bakhshian, S., and Romanak, K., 2021, DeepSense: a physics-guided deep learning paradigm for anomaly detection in soil gas data at geologic CO_2 storage sites: Environmental Science and Technology, v. 55, no. 22, p. 15531–15541, http://doi.org/10.1021/acs.est.1c04048.

Bakhshian, S., Rabbani, H. S., and Shokri, N., 2021, Physics-driven investigation of wettability effects on two-phase flow in natural porous media: recent advances, new insights, and future perspectives: Transport in Porous Media, v. 140, p. 85–106, http://doi.org/10.1007/s11242-021-01597-z.

Bhattacharya, S., 2021, A primer on machine learning in subsurface geosciences: Cham, Switzerland, Springer Nature, SpringerBriefs in Petroleum Geoscience & Engineering, 182 p., http://doi.org/10.1007/978-3-030-71768-1.

Blackford, J., Romanak, K. D., Huvenne, V. A. I., Lichtschlag, A., Strong, J. A., Alendal, G., Schütz, S. E., Oleynik, A., and Dankel, D. J., 2021, Efficient marine environmental characterisation to support monitoring of geological CO_2 storage: International Journal of Greenhouse Gas Control, v. 109, no. 103388, 16 p., http://doi.org/10.1016/j.ijggc.2021.103388.

Bump, A. P., Hovorka, S. D., and Meckel, T. A., 2021, Common risk segment mapping: streamlining exploration for carbon storage sites, with application to coastal Texas and Louisiana: International Journal of Greenhouse Gas Control, v. 111, no. 103457, 13 p., http://doi.org/10.1016/j.ijggc.2021.103457.

Chen, H., Zhang, C., Jia, N., Duncan, I., Yang, S., and Yang, Y. Z., 2021, A machine learning model for predicting the minimum miscibility pressure of CO_2 and crude oil system based on a support vector machine algorithm approach: Fuel, v. 290, no. 120048, 13 p., http://doi.org/10.1016/j.fuel.2020.120048.

Chen, Y., and Fomel, S., 2021, Nonstationary local signal-and-noise orthogonalization: Geophysics, v. 86, no. 5, p. V409–V418, http://doi.org/10.1190/geo2020-0151.1.

Chen, Y., Fomel, S., Wang, H., and Zu, S., 2021, 5D dealiased seismic data interpolation using nonstationary prediction-error filter: Geophysics, v. 86, no. 5, p. V419–V429, http://doi.org/10.1190/geo2020-0540.1.

Chen, Y., Saad, O. M., Bai, M., Liu, X., and Fomel, S., 2021, A compact program for 3D passive seismic source-location imaging: Seismological Research Letters, v. 92, no. 5, p. 3187–3201, http://doi.org/10.1785/0220210050.

Covault, J. A., Sylvester, Z., Ceyhan, C., and Dunlap, D. B., 2021, Giant meandering channel evolution, Campos deep-water salt basin, Brazil: Geosphere, v. 17, no. 6, p. 1869–1889, http://doi.org/10.1130/GES02420.1.

Dashtian, H., and Bakhshian, S., 2021, Effects of salinity and shear stress on clay deformation: a molecular dynamics study: The Journal of Chemical Physics, v. 155, no. 134304, 11 p., http://doi.org/10.1063/5.0062919.

Davletshin, A., Ko, L. T., Milliken, K., Periwal, P., Wang, C.-C., and Song, W., 2021, Detection of framboidal pyrite size distributions using convolutional neural networks: Marine and Petroleum Geology, v. 132, no. 105159, 11 p., http://doi.org/10.1016/j.marpetgeo.2021.105159.

Decker, L., and Fomel, S., 2021, A probabilistic approach to seismic diffraction imaging: Lithosphere, v. 2021, no. 1, article no. 6650633, 23 p., http://doi.org/10.2113/2021/6650633.

Duffy, O. B., Dooley, T. P., Hudec, M. R., Fernandez, N., Jackson, C. A.-L., and Soto, J. I., 2021, Principles of shortening in salt basins containing isolated minibasins: Basin Research, v. 33, no. 3, p. 2089–2117, http://doi.org/10.1111/bre.12550.

Ershadnia, R., Hajirezaie, S., Amooie, A., Wallace, C. D., Gershenzon, N. I., Hosseini, S. A., Sturmer, D. M., Ritzi, R. W., and Soltanian, M. R., 2021, CO_2 geological sequestration in multiscale heterogeneous aquifers: effects of heterogeneity, connectivity, impurity, and hysteresis: Advances in Water Resources, v. 151, no. 103895, 16 p., http://doi.org/10.1016/j.advwatres.2021.103895.

Ershadnia, R., Wallace, C. D., Hosseini, S. A., Dai, Z., and Soltanian, M. R., 2021, Capillary heterogeneity linked to methane lateral migration in shallow unconfined aquifers: Geophysical Research Letters, v. 48, no. 23, article no. e2021GL095685, 12 p., http://doi.org/10.1029/2021GL095685.

Ettinger, N. P., Larson, T. E., Kerans, C., Thibodeau, A. M., Hattori, K. E., Kacur, S. M., and Martindale, R. C., 2021, Ocean acidification and photic-zone anoxia at the Toarcian Oceanic Anoxic Event: insights from the Adriatic Carbonate Platform: Sedimentology, v. 68, no. 1, p. 63–107, http://doi.org/10.1111/sed.12786.

Fakhreddine, S., Prommer, H., Scanlon, B. R., Ying, S. C., and Nicot, J.-P., 2021, Mobilization of arsenic and other naturally occurring contaminants during managed aquifer recharge: a critical review: Environmental Science & Technology, v. 55, no. 4, p. 2208–2223, http://doi.org/10.1021/acs.est.0c07492.

Feng, D., Bakhshian, S., Wu, K., Song, Z., Ren, B., Li, J., Hosseini, S. A., and Li, X., 2021, Wettability effects on phase behavior and interfacial tension in shale nanopores: Fuel, v. 290, no. 119983, 17 p., http://doi.org/10.1016/j.fuel.2020.119983.

Fernandez, N., Duffy, O. B., Peel, F. J., and Hudec, M. R., 2021, Influence of minibasin obstruction on canopy dynamics in the northern Gulf of Mexico: Basin Research, v. 33, no. 1, p. 427–446, http://doi.org/10.1111/bre.12480.

Fildani, A., Kostic, S., Covault, J. A., Maier, K. L., Caress, D. W., and Paull, C. K., 2021, Exploring a new breadth of cyclic steps on distal submarine fans: Sedimentology, v. 68, no. 4, p. 1378–1399, http://doi.org/10.1111/sed.12803.

Fomel, S., and Kaur, H., 2021, Wave-equation time migration: Geophysics, v. 86, no. 1, p. s103–s111, http://doi.org/10.1190/geo2019-0822.1.

Gao, S., Nicot, J.-P., Hennings, P. H., La Pointe, P., Smye, K. M., Horne, E. A., and Dommisse, R., 2021, Low pressure buildup with large disposal volumes of oil field water: a flow model of the Ellenburger Group, Fort Worth Basin, northcentral Texas: AAPG Bulletin, v. 105, no. 12, p. 2575–2593, http://doi.org/10.1306/03252120159.

Gearon, J. H., and Young, M. H., 2021, Geomorphic controls on shrub canopy volume and spacing of creosote bush in northern Mojave Desert, USA: Landscape Ecology, v. 36, no. 2, p. 527–547, http://doi.org/10.1007/s10980-020-01149-8.

Gleeson, T., Wagener, T., Döll, P., Zipper, S. C., West, C., Wada, Y., Taylor, R., Scanlon, B. R., Rosolem, R., Rahman, S., and others, 2021, GMD perspective: the quest to improve the evaluation of groundwater representation in continental- to global-scale models: Geoscientific Model Development, v. 14, no. 12, p. 7545–7571, http://doi.org/10.5194/gmd-14-7545-2021.

Hattori, K. E., and Loucks, R. G., 2021, Cyclicity of carbonate shoaling sequences of the Lower Cretaceous Pettet Formation, Rusk County, East Texas: GCAGS Journal, v. 10, p. 31–46.

Heidari, M., Nikolinakou, M. A., Hudec, M. R., and Flemings, P. B., 2021, Impacts of vertical salt welding on pore pressure, stresses, and deformation near the weld: Marine and Petroleum Geology, v. 133, no. 105259, 18 p., http://doi.org/10.1016/j.marpetgeo.2021.105259.

Hennings, P., Dvory, N., Horne, E., Li, P., Savvaidis, A., and Zoback, M., 2021, Stability of the fault systems that host induced earthquakes in the Delaware Basin of West Texas and southeast New Mexico: The Seismic Record, v. 1, no. 2, p. 96–106, http://doi.org/10.1785/0320210020.

Hennings, P., Nicot, J.-P., Gao, R. S., DeShon, H. R., Lund Snee, J.-E., Morris, A. P., Brudzinski, M. R., Horne, E. A., and Breton, C., 2021, Pore pressure threshold and fault slip potential for induced earthquakes in the Dallas-Fort Worth area of north central Texas: Geophysical Research Letters, v. 48, no. 15, article no. e2021GL093564, 9 p., http://doi.org/10.1029/2021GL093564.

Horne, E. A., Hennings, P. H., and Zahm, C. K., 2021, Basement-rooted faults of the Delaware Basin and Central Basin Platform, Permian Basin, West Texas and southeastern New Mexico, in Callahan, O. A., and Eichhubl, P., eds., The geologic basement of Texas: a volume in honor of Peter T. Flawn: The University of Texas at Austin, Bureau of Economic Geology, Report of Investigations, v. 286, 36 p., http://doi.org/10.23867/RI0286C6.

Huang, G., Chen, X., Li, J., Luo, C., Wang, H., and Chen, Y., 2021, Pre-stack seismic inversion using a Rytov–WKBJ approximation: Geophysical Journal International, v. 227, no. 2, p. 1246–1267, http://doi.org/10.1093/gji/ggab281.

Huang, G., Chen, X., Li, J., Saad, O. M., Fomel, S., Luo, C., Wang, H., and Chen, Y., 2021, The slope-attribute-regularized high-resolution prestack seismic inversion: Surveys in Geophysics, v. 42, no. 3, p. 625–671, http://doi.org/10.1007/s10712-021-09636-6.

Hudec, M. R., and Soto, J. I., 2021, Piercement mechanisms for mobile shales: Basin Research, v. 33, no. 5, p. 2862–2882, http://doi.org/10.1111/bre.12586.

Hudec, M. R., Dooley, T. P., Burrel, L., Teixell, A., and Fernandez, N., 2021, An alternative model for the role of salt depositional configuration and preexisting salt structures in the evolution of the Southern Pyrenees, Spain: Journal of Structural Geology, v. 146, no. 104325, 16 p., http://doi.org/10.1016/j.jsg.2021.104325.

Kaur, H., Fomel, S., and Pham, N., 2021, A fast algorithm for elastic wave-mode separation using deep learning with generative adversarial networks (GANs): JGR Solid Earth, v. 126, no. 9, article no. e2020JB021123, 29 p., http://doi.org/10.1029/2020JB021123.

Kaur, H., Pham, N., and Fomel, S., 2021, Seismic data interpolation using deep learning with generative adversarial networks: Geophysical Prospecting, v. 69, no. 2, p. 307–326, http://doi.org/10.1111/1365-2478.13055.

Lawton, T. F., Blakey, R. C., Stockli, D. F., and Liu, L., 2021, Late Paleozoic (Late Mississippian–Middle Permian) sediment provenance and dispersal in western equatorial Pangea: Palaeogeography, Palaeoclimatology, Palaeoecology, v. 572, no. 110386, 35 p., http://doi.org/10.1016/j.palaeo.2021.110386.

Lawton, T., Giles, K., and Rowan, M., 2021, La Popa Basin, Nuevo León and Coahuila, Mexico: halokinetic sequences and diapiric structural kinematics in the field: Cham, Switzerland, Springer Nature, Springer Geology Field Guides, 98 p., http://doi.org/10.1007/978-3-030-79397-5.

Li, S., Zhu, H., Liang, J., Du, X., Wang, Q., Yao, T., and Zeng, H., 2021, Mixed siliciclastic-carbonate deposition and cyclical evolution of the Upper Shahejie Formation and its impact on reservoir development in the Eocene Huanghekou Sag, Bohai Bay Basin, East China: Interpretation, v. 9, no. 2, p. SC17–SC30, http://doi.org/10.1190/INT-2020-0171.1.

Li, Y., Zhang, T., Shen, B., Li, Z., Shao, D., and Lash, G. G., 2021, Carbon and sulfur isotope variations through the Upper Ordovician and Lower Silurian of South China linked to volcanism: Palaeogeography, Palaeoclimatology, Palaeoecology, v. 567, no. 110285, 15 p., http://doi.org/10.1016/j.palaeo.2021.110285.

Lin, N., and Brooks, R. E., 2021, Global liquified natural gas trade under energy transition: Energies, v. 14, no. 6617, 30 p., http://doi.org/10.3390/en14206617.

Liu, L., Ambrose, W. A., Lawton, T. F., and Stockli, D. F., 2021, Tectonic controls on the evolution of mixed carbonate-siliciclastic systems: insights from the late Palaeozoic Ouachita-Marathon foreland, United States: Basin Research, v. 33, no. 4, p. 2281–2302, http://doi.org/10.1111/bre.12557.

Liu, M., Xu, X., Scanlon, B. R., Sun, A. Y., and Wang, K., 2021, A modified evaporation model indicates that the effects of air warming on global drying trends have been overestimated: JGR Atmospheres, v. 126, no. e2021JD035153, 17 p., http://doi.org/10.1029/2021JD035153.

Liu, X., Tang, Q., Hosseini-Moghari, S.-M., Shi, X., Lo, M.-H., and Scanlon, B., 2021, GRACE satellites enable long-lead forecasts of mountain contributions to streamflow in the low-flow season: Remote Sensing, v. 13, no. 1993, 12 p., http://doi.org/10.3390/rs13101993.

Loucks, R. G., and Peng, S., 2021, Matrix reservoir quality of the Upper Cretaceous Austin Chalk Group and evaluation of reservoir-quality analysis methods; northern onshore gulf of Mexico, U.S.A.: Marine and Petroleum Geology, v. 134, no. 105323, 11 p., http://doi.org/10.1016/j.marpetgeo.2021.105323.

Loucks, R. G., Reed, R. M., Ko, L. T., Zahm, C. K., and Larson, T. E., 2021, Micropetrographic characterization of a siliciclastic-rich chalk; Upper Cretaceous Austin Chalk Group along the onshore northern Gulf of Mexico, USA: Sedimentary Geology, v. 412, no. 105821, 19 p., http://doi.org/10.1016/j.sedgeo.2020.105821.

Loucks, R. G., Zahm, C. K., Larson, T. E., Zahm, L. C., and Peng, S., 2021, Stratal architecture, lithofacies, environmental setting, depositional processes, and associated geological characteristics of the Upper Cretaceous Austin Chalk in Louisiana: GCAGS Journal, v. 10, p. 47–75.

MacDonald, A. M., Lark, R. M., Taylor, R. G., Abiye, T., Fallas, H. C., Favreau, G., Goni, I. B., Kebede, S., Scanlon, B. R., and Sorensen, J. P. R., 2021, Mapping groundwater recharge in Africa from ground observations and implications for water security: Environmental Research Letters, v. 16, no. 034012, 14 p., http://doi.org/10.1088/1748-9326/abd661.

Madugula, A. C. S., Sachde, D., Hovorka, S. D., Meckel, T. A., and Benson, T. J., 2021, Estimation of CO_2 emissions from petroleum refineries based on the total operable capacity for carbon capture applications: Chemical Engineering Journal Advances, v. 8, no. 100162, 9 p., http://doi.org/10.1016/j.ceja.2021.100162.

Meckel, T. A., Bump, A. P., Hovorka, S. D., and Treviño, R. H., 2021, Carbon capture, utilization, and storage hub development on the Gulf Coast: Greenhouse Gases: Science and Technology, v. 11, no. 4, p. 619–632, http://doi.org/10.1002/ghg.2082.

Mehrnegar, N., Jones, O., Singer, M. B., Schumacher, M., Jagdhuber, T., Scanlon, B. R., Rateb, A., and Forootan, E., 2021, Exploring groundwater and soil water storage changes across the CONUS at 12.5 km resolution by a Bayesian integration of GRACE data into W3RA: Science of The Total Environment, v. 758, no. 143579, 16 p., http://doi.org/10.1016/j.scitotenv.2020.143579.

Milliken, K. L., Zhang, T., Chen, J., and Ni, Y., 2021, Mineral diagenetic control of expulsion efficiency in organic-rich mudrocks, Bakken Formation (Devonian-Mississippian), Williston Basin, North Dakota, U.S.A.: Marine and Petroleum Geology, v. 127, no. 104869, 24 p., http://doi.org/10.1016/j.marpetgeo.2020.104869.

Morris, A. P., Hennings, P. H., Horne, E. A., and Smye, K. M., 2021, Stability of basement-rooted faults in the Delaware Basin of Texas and New Mexico, USA: Journal of Structural Geology, v. 149, no. 104360, 18 p., http://doi.org/10.1016/j.jsg.2021.104360.

Ni, H., and Meckel, T. A., 2021, Characterizing the effect of capillary heterogeneity on multiphase flow pulsation in an intermediate-scale beadpack experiment using time series clustering and frequency analysis: Water Resources Research, v. 57, no. 11, article no. e2021WR030876, 17 p., http://doi.org/10.1029/2021WR030876.

Ni, H., Møyner, O., Kurtev, K. D., and Benson, S. M., 2021, Quantifying CO_2 capillary heterogeneity trapping through macroscopic percolation simulation: Advances in Water Resources, v. 155, no. 103990, 17 p., http://doi.org/10.1016/j.advwatres.2021.103990.

Nicot, J.-P., 2021, Hydrogeology of the Texas basement, in Callahan, O. A., and Eichhubl, P., eds., The geologic basement of Texas: a volume in honor of Peter T. Flawn: The University of Texas at Austin, Bureau of Economic Geology, Report of Investigations, v. 286, 13 p., http://doi.org/10.23867/RI0286C5.

Nikolinakou, M. A., and Whittle, A. J., 2021, Constitutive model of structural alteration and swelling behavior for Old Alluvium: Engineering Geology, v. 293, no. 106307, 16 p., http://doi.org/10.1016/j.enggeo.2021.106307.

Oboué, Y. A. S. I., and Chen, Y., 2021, Enhanced low-rank matrix estimation for simultaneous denoising and reconstruction of 5D seismic data: Geophysics, v. 86, no. 5, p. V459–V470, http://doi.org/10.1190/GEO2020-0773.1.

Ogiesoba, O. C., and Ambrose, W. A., 2021, A systematic approach to identifying hydrocarbon sweet spots using integrated seismic multiattribute, wireline-log, and core analyses: case study from the Upper Cretaceous Taylor Serbin field, southeast Texas: The University of Texas at Austin, Bureau of Economic Geology, Report of Investigations, v. 287, 76 p.

Olariu, C., Zhou, C., Steel, R., Zhang, Z., Yuan, X., Zhang, J., Chen, S., Cheng, D., and Kim, W., 2021, Controls on the stratal architecture of lacustrine delta successions in low-accommodation conditions: Sedimentology, v. 68, no. 5, p. 1941–1963, http://doi.org/10.1111/sed.12838.

Olson, T., and Milliken, K. L., 2021, Petrographic imaging methods for characterizing mudstone reservoirs, in Sorkhabi, R., ed., Encyclopedia of petroleum geoscience: Springer Nature Switzerland, Encyclopedia of Earth Sciences series, 29 p., http://doi.org/10.1007/978-3-319-02330-4_309-1.

Paine, J. G., Costard, L., Andrews, J., Averett, A., Saylam, K., and Hupp, J., 2021, Determining annual to decadal subsidence areas and rates using airborne lidar, GPS surveys, and topographic maps at the Wink sinkholes, West Texas, in Johnson, K. S., Land, L., and Decker, D. D., eds., Evaporite karst in the Greater Permian Evaporite Basin (GPEB) of Texas, New Mexico, Oklahoma, Kansas, and Colorado: Oklahoma Geological Survey, Circular, v. 113, p. 93-103.

Pantaleone, S., and Bhattacharya, S., 2021, Hydrologic and geomechanical characterization of the deep sedimentary rocks and basement for safe carbon sequestration in the Cook Inlet Basin, Alaska: International Journal of Greenhouse Gas Control, v. 106, no. 103243, 10 p., http://doi.org/10.1016/j.ijggc.2020.103243.

Peng, J., Fu, Q., Larson, T. E., and Janson, X., 2021, Trace-elemental and petrographic constraints on the severity of hydrographic restriction in the silled Midland Basin during the late Paleozoic ice age: Geological Society of America Bulletin, v. 133, no. 1-2, p. 57–73, http://doi.org/10.1130/B35336.1.

Peng, S., 2021, Advanced understanding of gas flow and the Klinkenberg effect in nanoporous rocks: Journal of Petroleum Science and Engineering, v. 206, no. 109047, 14 p., http://doi.org/10.1016/j.petrol.2021.109047.

Peng, S., Shevchenko, P., Periwal, P., and Reed, R. M., 2021, Water-oil displacement in shale: new insights from a comparative study integrating imbibition tests and multiscale imaging: Society of Petroleum Engineers Journal, v. 26, no. 5, paper no. SPE-205515-PA, p. 3285–3299, http://doi.org/10.2118/205515-PA.

Pham, N., and Fomel, S., 2021, Uncertainty and interpretability analysis of encoder-decoder architecture for channel detection: Geophysics, v. 86, no. 4, p. O49–O58, http://doi.org/10.1190/geo2020-0409.1.

Prieto, M. I., Moscardelli, L., and Wood, L., 2021, Deepwater sedimentary bedforms in a mobile substrate terrain: examples from the central Gulf of Mexico Basin: Interpretation, v. 9, no. 2, p. SB33–SB48, http://doi.org/10.1190/int-2020-0128.1.

Ramirez, S. G., Hayman, N. W., Gulick, S. P. S., Milliken, K. L., Stockli, D. F., and Masago, H., 2021, Sediment provenance, routing and tectonic linkages in the Nankai forearc region, Japan: Basin Research, v. 33, no. 6, p. 3231–3255, http://doi.org/10.1111/bre.12601.

Rateb, A., Scanlon, B. R., and Kuo, C.-Y., 2021, Multi-decadal assessment of water budget and hydrological extremes in the Tigris-Euphrates Basin using satellites, modeling, and in-situ data: Science of The Total Environment, v. 76, no. 144337, 11 p., http://doi.org/10.1016/j.scitotenv.2020.144337.

Ren, B., and Duncan, I. J., 2021, Maximizing oil production from water alternating gas (CO_2) injection into residual oil zones: the impact of oil saturation and heterogeneity: Energy, v. 222, no. 119915, 13 p., http://doi.org/10.1016/j.energy.2021.119915.

Ren, G., Ren, B., Li, S., and Zhang, C., 2021, Unlock the potentials to further improve CO_2 storage and utilization with supercritical CO_2 emulsions when applying CO_2-philic surfactants: Sustainable Chemistry, v. 2, no. 1, p. 127–148, http://doi.org/10.3390/suschem2010009.

Romanak, K. D., Fridahl, M., and Dixon, T., 2021, Attitudes on carbon capture and storage (CCS) as a mitigation technology within the UNFCCC: Energies, v. 14, no. 3, article no. 629, 16 p., http://doi.org/10.3390/en14030629.

Saad, O. M., Bai, M., and Chen, Y., 2021, Uncovering the microseismic signals from noisy data for high-fidelity 3D source-location imaging using deep learning: Geophysics, v. 86, no. 6, p. KS161–KS173, http://doi.org/10.1190/GEO2021-0021.1.

Saad, O. M., Huang, G., Chen, Yufeng, Savvaidis, A., Fomel, S., Pham, N., and Chen, Yangkang, 2021, SCALODEEP: a highly generalized deep learning framework for real-time earthquake detection: JGR Solid Earth, v. 126, no. 4, article no. e2020JB021473, 18 p., http://doi.org/10.1029/2020JB021473.

Scanlon, B. R., Rateb, A., Pool, D. R., Sanford, W., Save, H., Sun, A., Long, D., and Fuchs, B., 2021, Effects of climate and irrigation on GRACE-based estimates of water storage changes in major US aquifers: Environmental Research Letters, v. 16, no. 9, 14 p., http://doi.org/10.1088/1748-9326/ac16ff.

Senger, K., Betlem, P., Birchall, T., Buckley, S. J., Coakley, B., Eide, C. H., Flaig, P. P., Forien, M., Galland, O., Gonzaga, L., Jr., and others, 2021, Using digital outcrops to make the high Arctic more accessible through the Svalbox database: Journal of Geoscience Education, v. 69, no. 2, p. 123–137, http://doi.org/10.1080/10899995.2020.1813865.

Sharman, G. R., Covault, J. A., Stockli, D. F., Sickmann, Z. T., Malkowski, M. A., and Johnstone, S. A., 2021, Detrital signals of coastal erosion and fluvial sediment supply during glacio-eustatic sea-level rise, Southern California, USA: Geology, v. 49, no. 12, p. 1501–1505, http://doi.org/10.1130/G49430.1.

Shi, Y., Wu, X., and Fomel, S., 2021, Interactively tracking seismic geobodies with a deep-learning flood-filling network: Geophysics, v. 86, no. 1, p. A1–A5, http://doi.org/10.1190/geo2020-0042.1.

Shokouhi, P., Kumar, V., Prathipati, S., Hosseini, S. A., Giles, C. L., and Kifer, D., 2021, Physics-informed deep learning for prediction of CO_2 storage site response: Journal of Contaminant Hydrology, v. 241, no. 103835, 13 p., http://doi.org/10.1016/j.jconhyd.2021.103835.

Shuster, M. W., Zahm, C. K., and Hennings, P. H., 2021, Oil and gas in fractured crystalline igneous and metamorphic rocks: global overview and examples from Texas, in Callahan, O. A., and Eichhubl, P., eds., The geologic basement of Texas: a volume in honor of Peter T. Flawn: The University of Texas at Austin, Bureau of Economic Geology, Report of Investigations, v. 286, 68 p., http://doi.org/10.23867/RI0286C3.

Smye, K. M., Hennings, P. H., and Horne, E. A., 2021, Variations in vertical stress in the Permian Basin region: AAPG Bulletin, v. 105, no. 10, p. 1893–1907, http://doi.org/10.1306/10092019189.

Smye, K., Banerji, D. A., Eastwood, R., McDaid, G., and Hennings, P., 2021, Lithology and reservoir properties of the Delaware Mountain Group of the Delaware Basin and implications for saltwater disposal and induced seismicity: Journal of Sedimentary Research, v. 91, no. 11, p. 1113–1132, http://doi.org/10.2110/jsr.2020.134.

Song, L., Bhattacharya, S., Webb, Z., Fowler, A., and Lee, V., 2021, Preservation of organic carbon in the Cretaceous Hue Shale on the North Slope of Alaska: insights from pyrite morphology: International Journal of Coal Geology, v. 235, no. 103678, 11 p., http://doi.org/10.1016/j.coal.2021.103678.

Soto, J. I., Heidari, M., and Hudec, M. R., 2021, Proposal for a mechanical model of mobile shales: Scientific Reports, v. 11, no. 23785, 11 p., http://doi.org/10.1038/s41598-021-02868-x.

Soto, J. I., Hudec, M. R., Mondol, N. H., and Heidari, M., 2021, Shale transformations and physical properties—implications for seismic expression of mobile shales: Earth-Science Reviews, v. 220, no. 103746, 23 p., http://doi.org/10.1016/j.earscirev.2021.103746.

Soto-Kerans, P., Loucks, R. G., and Kerans, C., 2021, Deeper-water deposition in intrashelf basins: example from the Lower Cretaceous (Albian) upper Glen Rose Formation in the Houston trough, eastern Texas: AAPG Bulletin, v. 105, no. 7, p. 1405–1434, http://doi.org/10.1306/12222019055.

Spruženiece, L., Späth, M., Urai, J. L., Ukar, E., Selzer, M., and Nestler, B., 2021, Wide-blocky veins explained by dependency of crystal growth rate on fracture surface type: insights from phase-field modeling: Geology, v. 49, no. 6, p. 641–646, http://doi.org/10.1130/G48472.1.

Spruženiece, L., Späth, M., Urai, J. L., Ukar, E., Selzer, M., Nestler, B., and Schwedt, A., 2021, Formation of wide-blocky calcite veins by extreme growth competition: Journal of the Geological Society, v. 178, no. 2, article no. jgs2020-104, 17 p., http://doi.org/10.1144/jgs2020-104.

Sun, A. Y., Jiang, P., Mudunuru, M. K., and Chen, X., 2021, Explore spatio-temporal learning of large sample hydrology using graph neural networks: Water Resources Research, v. 57, no. 2021WR030394, 23 p., http://doi.org/10.1029/2021WR030394.

Sun, A. Y., Scanlon, B. R., Save, H., and Rateb, A., 2021, Reconstruction of GRACE total water storage through automated machine learning: Water Resources Research, v. 57, no. 2, article no. e2020WR028666, 20 p., http://doi.org/10.1029/2020WR028666.

Sylvester, Z., Durkin, P. R., Hubbard, S. M., and Mohrig, D., 2021, Autogenic translation and counter point bar deposition in meandering rivers: Geological Society of America Bulletin, v. 133, no. 11–12, p. 2439–2456, http://doi.org/10.1130/B35829.1.

Tavassoli, S., Krishnamurthy, P., Beckham, E., Meckel, T., and Sepehrnoori, K., 2021, Carbon dioxide storage in deltaic saline aquifers: invasion percolation and compositional simulation: Society of Petroleum Engineers Reservoir Evaluation & Engineering, v. 24, no. 3, article no. SPE-196723-PA, 13 p., http://doi.org/10.2118/196723-PA.

Wang, J., Zeng, L., Yang, X., Liu, C., Wang, K., Zhang, R., Chen, X., Qu, Y., Laubach, S. E., and Wang, Q., 2021, Fold-related fracture distribution in Neogene, Triassic, and Jurassic sandstone outcrops, northern margin of the Tarim Basin, China: guides to deformation in ultradeep tight sandstone reservoirs: Lithosphere, v. 2021, no. Special 1, article no. 8330561, 17 p., http://doi.org/10.2113/2021/8330561.

Wang, S., Qin, C., Feng, Q., Javadpour, F., and Rui, Z., 2021, A framework for predicting the production performance of unconventional resources using deep learning: Applied Energy, v. 295, no. 117016, 21 p., http://doi.org/10.1016/j.apenergy.2021.117016.

Wang, S., Yao, X., Feng, Q., Javadpour, F., Yang, Y., Xue, Q., and Li, X., 2021, Molecular insights into carbon dioxide enhanced multi-component shale gas recovery and its sequestration in realistic kerogen: Chemical Engineering Journal, v. 425, no. 130292, 17 p., http://doi.org/10.1016/j.cej.2021.130292.

Wendt, D. E., Van Loon, A. F., Scanlon, B. R., and Hannah, D. M., 2021, Managed aquifer recharge as a drought mitigation strategy in heavily-stressed aquifers: Environmental Research Letters, v. 16, no. 1, article no. 014046, 13 p., http://doi.org/10.1088/1748-9326/abcfe1.

Wu, R.-J., Lo, M.-H., and Scanlon, B. R., 2021, The annual cycle of terrestrial water storage anomalies in CMIP6 models evaluated against GRACE data: Journal of Climate, v. 34, no. 20, p. 8205–8217, http://doi.org/10.1175/jcli-d-21-0021.1.

Xu, W., Li, Z., Li, H., Zhang, C., Zhao, M., Zeng, H., and Ding, Y., 2021, The relationship between source supply and mixed deposition of siliciclastic and carbonate: first to second member of the Shahejie Formation, Paleogene, Bohai Sea area, China: Interpretation, v. 9, no. 2, p. SC45–SC52, http://doi.org/10.1190/INT-2020-0182.1.

Yao, Y., Zheng, C., Andrews, C. B., Scanlon, B. R., Kuang, X., Zeng, Z., Jeong, S.-J., Lancia, M., Wu, Y., and Li, G., 2021, Role of groundwater in sustaining northern Himalayan rivers: Geophysical Research Letters, v. 48, no. e2020GL092354, 10 p., http://doi.org/10.1029/2020gl092354.

Zeng, H., He, Y., and Zeng, L., 2021, Impact of sedimentary facies on machine learning of acoustic impedance from seismic data: lessons from a geologically realistic 3D model: Interpretation, v. 9, no. 3, p. 1009–1024, http://doi.org/10.1190/int-2021-0035.1.

Zhang, J., Ambrose, W. A., and Xie, W., 2021, Applying convolutional neural networks to identify lithofacies of large-n cores from the Permian Basin and Gulf of Mexico: the importance of the quantity and quality of training data: Marine and Petroleum Geology, v. 133, no. 105307, 6 p., http://doi.org/10.1016/j.marpetgeo.2021.105307.

Zhang, J., Flaig, P. P., Wartes, M., Aschoff, J., and Shuster, M., 2021, Integrating stratigraphic modelling, inversion analysis, and shelf-margin records to guide provenance analysis: an example from the Cretaceous Colville Basin, Arctic Alaska: Basin Research, v. 33, no. 3, p. 1954–1966, http://doi.org/10.1111/bre.12543.

Zhang, T., Fu, Q., Sun, X., Hackley, P. C., Ko, L. T., and Shao, D., 2021, Meter-scale lithofacies cycle and controls on variations in oil saturation, Wolfcamp A, Delaware and Midland Basins: AAPG Bulletin, v. 105, no. 9, p. 1821–1846, http://doi.org/10.1306/01152120065.

Zhang, Y., Zhou, D., Wei, W., Frame, J. M., Sun, H., Sun, A. Y., and Chen, X., 2021, Hierarchical fractional advection-dispersion equation (FADE) to quantify anomalous transport in river corridor over a broad spectrum of scales: theory and applications: Mathematics, v. 9, no. 7, article no. 790, 15 p., http://doi.org/10.3390/math9070790.

Zhong, Z., Sun, A. Y., Ren, B., and Wang, Y., 2021, A deep-learning-based approach for reservoir production forecast under uncertainty: Society of Petroleum Engineers Journal, v. 26, no. 3, p. 1314–1340, http://doi.org/10.2118/205000-PA.

Transitions

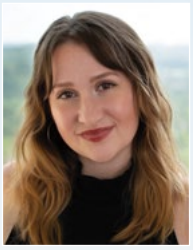
Lorena Moscardelli
Research Scientist

Lorena Moscardelli has returned to the Bureau as the Principal Investigator of the State of Texas Advanced Resource Recovery (STARR) program. In her new role, Moscardelli will lead STARR as it supports oil and gas exploration and production in Texas, benefiting the state by increasing severance tax and royalty revenues. The STARR program also supports critical environmental studies throughout Texas.

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 2021 was no exception as the Bureau brought a diverse group of seven new people on board. Please help us welcome them to the Bureau!

Mahdi Haddad
Research Associate



Elyse Vane
Publications Editor

Jerri Kelly
Executive Assistant

Ashraf Rateb
Research Scientist Associate IV

Atta Ur Rehman
Postdoctoral Fellow

Bede "JJ" Uku
Earthquake Management System Administrator

Retirements

The Bureau thanks 2021's retirees for their years of invaluable service and wishes them a happy retirement. They will all be missed!

Amanda Masterson
Manager, The Bureau Store

Amanda Masterson retired in November after 45 years of remarkable service as an editor, librarian, and publication sales manager. Her pleasant and gracious demeanor, as well as her mastery of geoscience proofreading, editing, and indexing, added excellence to decades of Bureau research publications. Amanda's knowledge of Bureau archives and history along with her dedication to researching questions for others made her an invaluable contributor.

Bill Ambrose
Senior Research Scientist

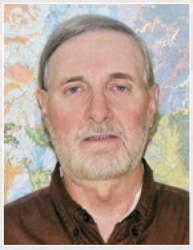
Theresa Caillouet
Executive Assistant

Richard Gutierrez
Warehouse Supervisor

Darrell Haynes
Stores Clerk II

Tucker Hentz
Research Scientist Associate V

Sammy Jacobo
Senior Administrative Associate



Randy McDonald
Warehouse Supervisor

In Memoriam

David Boling
Senior Department Payroll Representative
12 years

David Douglas Boling, 53, passed away May 17, 2021. Spending 27 years at The University of Texas at Austin, David easily cultivated a varied array of friends and colleagues over his many years of hard work. David was a highly intelligent man, but he was still notorious for making silly jokes that would make everyone who heard them (including himself) laugh uncontrollably. His endless talents never failed to amaze. Whether he was performing magic tricks, singing, or playing any type of instrument he could find, his antics would always leave people with a smile on their face. David was an avid collector of coins and deeply appreciated the beauty and history they held. He was an adventurer at heart and could often be found on cruises or cross-country trips with his beloved family. He was a Godly man who could light up a room with his contagious smile. His kindness and selflessness is embodied in every person whose life he touched, and he will not be soon forgotten.

John Lester Chin
Research Scientist Associate III
2 years

Margaret Evans
Technical Illustrator II
22 years

Walter Keene Linscott Ferguson
Research Associate
1 year

Edgar Guevara
Research Scientist
33 years

Kenley Conrad Schroeder
Warehouse Supervisor
7 years

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://facilitiesservices.utexas.edu/divisions/support/urban-forestry/memorial-trees-map.

2021 Visiting Committee

The Bureau of Economic Geology's Visiting Committee includes leaders from industry, state agencies, academia, and nonprofit organizations, all possessing a deep appreciation for the work of the Bureau and the many ways it serves the public by undertaking the pursuit of energy, environmental, and economics research that matters.

Led by new Chair Claudia Hackbarth, the Visiting Committee came together in August for a virtual annual meeting. The Committee was briefed on how the Bureau has been successfully navigating the impacts of COVID-19 and the downturn in the energy industry while at the same time exploring various new avenues for research and support. The meeting agenda was designed to share potential opportunities for future research and to solicit the Committee members' perspectives on innovative research thrusts and untapped funding resources.

Current challenges for the Bureau of Economic Geology may not be insignificant, but the clear message coming out of this year's Visiting Committee meeting was that the Bureau, with its extensive expertise and broad capacity, is well positioned and ready to capitalize on a variety of new geoscience research opportunities going forward.

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.

From top left to right: Ms. Carol Lloyd (Exxon Mobil Corporation), Mr. James "Jim" Farnsworth (Beacon Offshore, Azimuth Capital), Dr. Charles "Chuck" Williamson (Infinium Electrofuels), Mr. Richard "Dick" Stoneburner (Pine Brook Partners), Dr. Claudia Hackbarth, Chair (Shell Oil Company, Retired), Chairman Jon Niermann (Texas Commission on Environmental Quality), Ms. Marilu Hastings (Cynthia and George Mitchell Foundation), Mr. Elliott Pew (Enerplus Corporation, Retired), Mr. Scott Anderson (Environmental Defense Fund), Mr. Bud Scherr (Valence Operating Company), Dr. Scott W. Tinker (Bureau of Economic Geology), Ms. Kathleen Jackson (Texas Water Development Board), Mr. Michael "Mike" Ming (Ming Energy Partners, LLC), Dr. Dan Domeracki (UNC Kenan-Flagler Business School), Mr. Tim Brittan (Infinity Oil & Gas, Inc.), and Mr. Bill Black (Railroad Commission of Texas, represented Commissioner Christi Craddick).

Finances

Director
Scott W. Tinker

Associate Directors
Mark Shuster,
Energy Division
Ken Wisian,
Environmental Division
Jay P. Kipper, Operations

Website
https://www.beg.utexas.edu

Media Manager
Jason Suarez

Editor
Elyse Vane

Senior Graphic Designer
Jamie H. Coggin

External & Governmental Affairs
Mark W. Blount, CFRE
512-471-1509
mark.blount@beg.utexas.edu

Public Information and Outreach
Linda Ruiz McCall
512-471-0320
linda.mccall@beg.utexas.edu

Austin Core Research Center
Nathan Ivicic
512-475-9561
nathan.ivicic@beg.utexas.edu

Houston Core Research Center
Nathan Ivicic
512-475-9561
nathan.ivicic@beg.utexas.edu

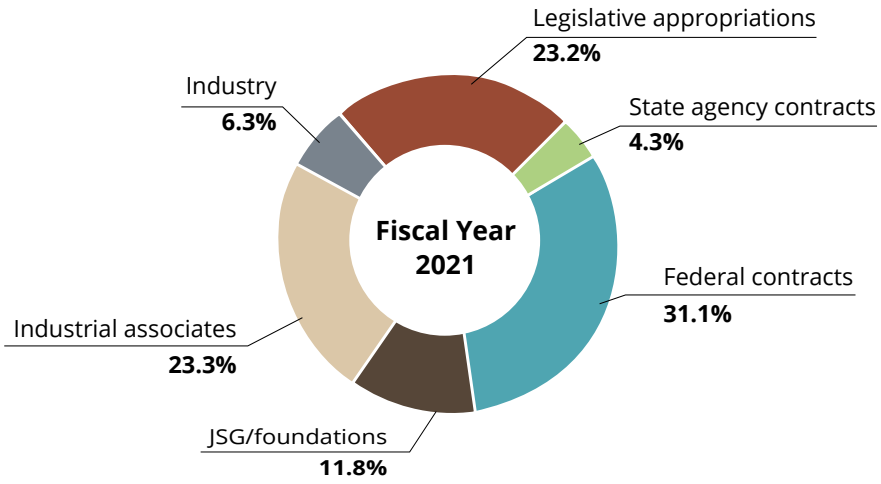
Midland Core Research Center
Andrew Faigle
432-686-9902
andrew.faigle@beg.utexas.edu

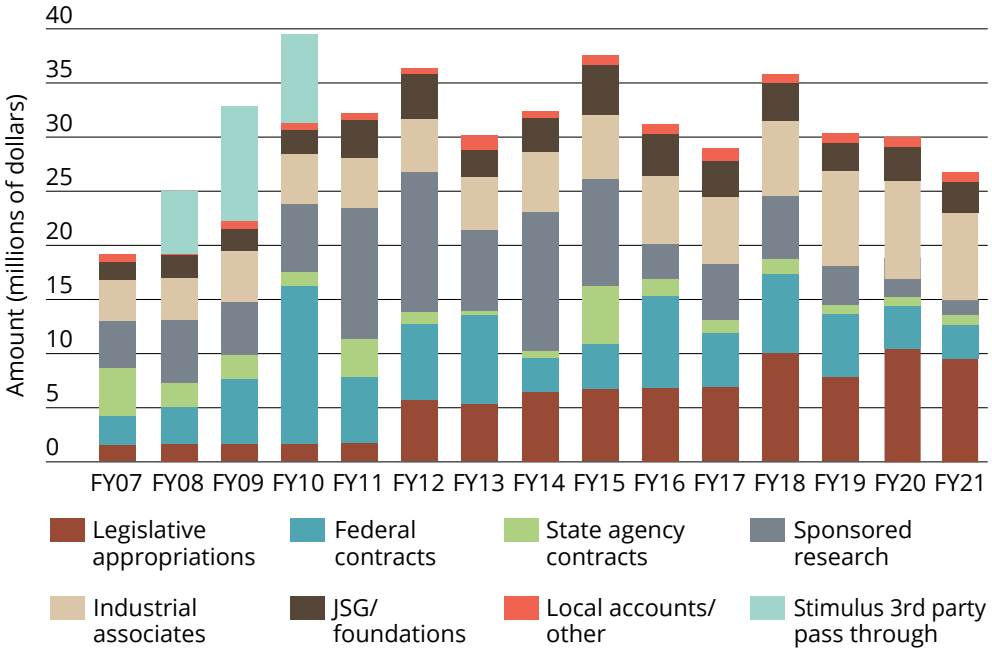
Geophysical Log Facility
Daniel H. Ortuño
512-471-7139
daniel.ortuno@beg.utexas.edu

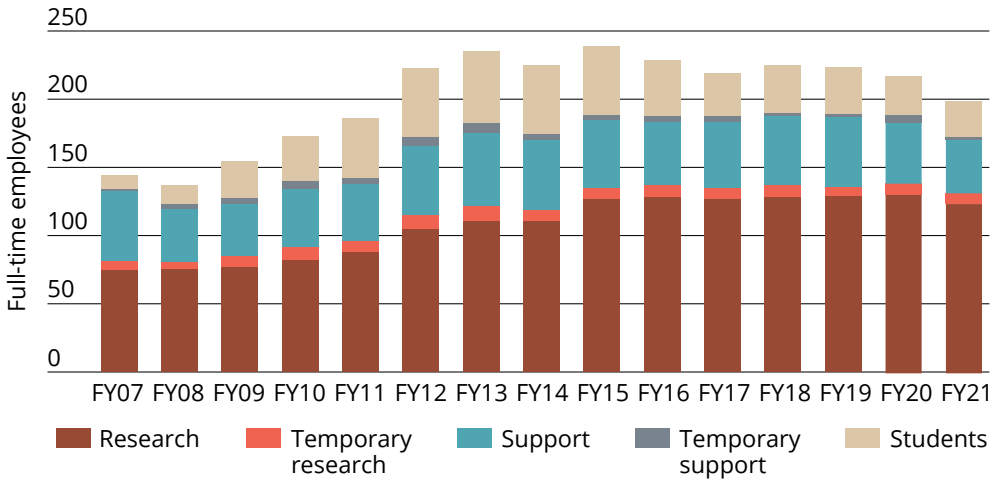
Publications, The Bureau Store
512-471-7144
pubsales@beg.utexas.edu

Research and Administrative Facilities
J. J. Pickle Research Campus
10100 Burnet Road, Bldg. 130
Austin, Texas 78758-4445
512-471-1534, Switchboard
512-471-0140, Fax

Mailing Address
Bureau of Economic Geology
The University of Texas at Austin
PO Box X
Austin, Texas 78713-8924







BUREAU OF ECONOMIC GEOLOGY
The University of Texas at Austin
Jackson School of Geosciences
PO Box X
Austin, Texas 78713-8924
Address Service Requested

Nonprofit Org.
U.S. POSTAGE
PAID
PERMIT 391
Austin, Texas

Scott W. Tinker, Director