

Global Reach, Wide-Ranging Research



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Message from the Director

Measures of quality in academia include such things as reputation, impact, and reach.

Reputation is built from participation in professional meetings; publication in journals and books; awarding of medals and fellowships; and competing for and receiving funding from various government agencies, industries, and foundations. Impact can be harder to quantify but includes citations in the published literature, patents, licensing and commercialization, and in some cases real-world application of research.

But what is reach, and why does it matter? At the Bureau, our global reach begins with staff diversity: cultural, political, religious, socioeconomic, and educational. Over 25 nations from six continents are represented on our permanent staff. Postdocs and students broaden that representation further. These talented individuals serve as a living network of emissaries weaving the Bureau into the fabric of universities, industry, governments, and the global public.

Reach is also defined by geography. Geology knows no geopolitical boundaries, and our reach in the field is literally and figuratively boundless. Fieldwork is conducted on mountains and in canyons; along coasts and on islands; across deserts and glaciers; in oceans, lakes, and rivers; from the air, on land, and under the sea. We even go beyond global boundaries to investigate other planets and moons.

Reach also involves science. Bureau professionals have backgrounds in the geoscience disciplines of geology, geophysics, seismology, petrophysics, geochemistry, and more. Our ranks further include petroleum, chemical, mechanical, and civil engineers; energy and environmental economists; doctors of medicine; and biologists.

Why is reach important? Because reach measures relevance and influence. In academia there exists the risk of becoming isolated—somewhat walled off from the world in a knowledge quest. Reach knocks down walls and builds global pathways.

We are privileged to be part of the Bureau of Economic Geology at The University of Texas at Austin. It is not only important but in many ways our duty to share our ideas and knowledge, and to do our best to make the world a better place.

We strive to do that every day.

A handwritten signature in black ink, appearing to read "Scott W. Fisher".



Advanced Energy Consortium

Exploring the Subsurface with Nanotech

Reaching across the globe to unite diverse teams of researchers in finding solutions to problems at the intersection of two distinct scientific disciplines might seem like an

impossible undertaking, but not for the Bureau of Economic Geology.

“What if we could insert ‘smart dust’ down a borehole that would tell us more about the chemical and physical makeup of the subsurface?”

That was the big question posed 10 years ago by Bureau director **Scott W. Tinker** that launched the **Advanced Energy Consortium (AEC)**, a complex merger of nanotechnology and oil and gas exploration that has produced some fascinating research. The AEC brings together scientists, graduate students, and postdocs from around the world, all focused on answering Tinker’s “big question.” These researchers are developing practical applications to real-world problems (“use cases”) that supporting partners believe nanotechnology can better address.

The use cases involve using nanoparticles to map fracture systems, track waterfloods, and increase hydrofracturing effectiveness. The AEC has also developed time-released nanoscale payload-delivery particles to transport important cargo to specific parts of the subsurface reservoir. AEC researchers also developed a tiny electronic nanosensor that can report downhole conditions such as temperature and pressure. In 2017, researchers conducted numerous field tests of these nanotechnologies to better simulate the harsh and complex conditions encountered in the subsurface.

Sponsoring partners of the AEC have invested over \$50 million in these productive research efforts over the years. Sponsors in 2017 include ExxonMobil, Shell, Total, Repsol, BHP Billiton, and the U.S. Department of Energy through Sandia National Laboratories.

For more information about how you, your company, or your institution can become involved in this innovative research, please contact **Jay Kipper** at jay.kipper@beg.utexas.edu.



Multicore microsponges encapsulate and delay release of 12M HCl cargo (upper). Autonomous electronic nanosensors (lower).



EarthDate

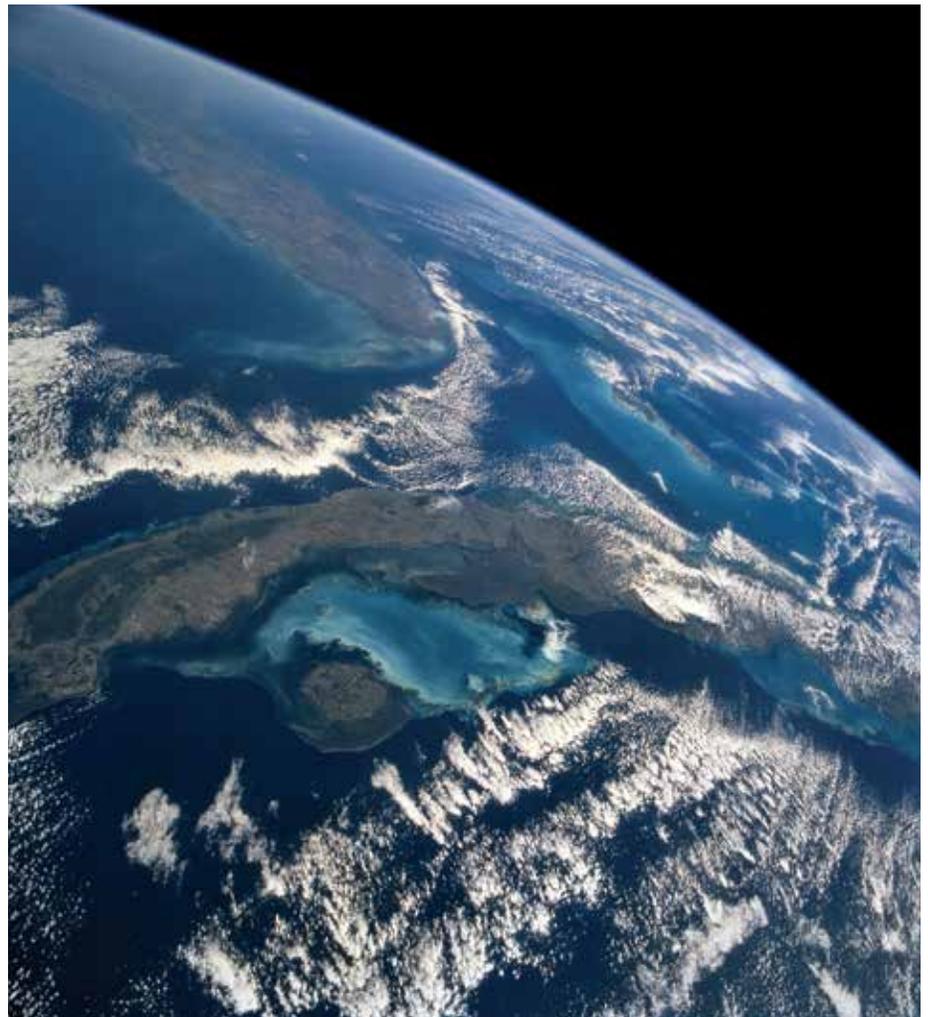
Reaching the World on the Radio

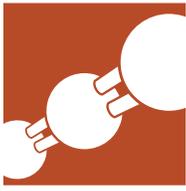
Expanding its mission to reach as many people as possible with accurate and educational geoscience information, the Bureau of Economic Geology launched a new radio program in 2017, *EarthDate*, which provides a fun and informative way for listeners to discover the natural wonders of Earth, both past and present. Debuting in April, *EarthDate* now airs on over 250 radio stations nationally, as well as on stations in Canada, New Zealand, and the Philippines.

Hosted by **Scott W. Tinker**, State Geologist of Texas and director of the Bureau, *EarthDate* offers listeners of all ages and backgrounds fresh perspectives on the geology, environment, and major geologic events of our fascinating planet. Recent episodes have examined phenomena like the 2017 solar eclipse and the effects of magnetic storms; historical happenings like “The Year Without a Summer” and the five Great Extinctions; Earth’s creatures like our 3-million-year-old ancestor, Lucy, and a 65-million-year-old baby sauropod; and modern marvels like the minerals in smartphones and exactly how GPS helps us navigate.

To listen to episodes or download fact sheets (especially helpful for classroom instruction), visit <http://earthdate.org>. To see if your city carries *EarthDate*, visit <http://earthdate.org/about>.

For information on sponsorship opportunities, please contact **Mark W. Blount** at mark.blount@beg.utexas.edu or 512-471-1509.





Gulf Coast Carbon Center Mapping CO₂ Storage in 3D

The Bureau's **Gulf Coast Carbon Center** (GCCC) is renowned internationally as one of the foremost academic research institutions investigating carbon capture and storage. In 2017, the GCCC's **Tip Meckel** led a crew of 20 on a 6-day data-collection cruise off Japan's north island of Hokkaido. Meckel's team arrived in Japan with unique acoustic instrumentation for three-dimensional

mapping of the geology below the seafloor with ultra-high resolution.

The key to the equipment is a set of four 25-m-long streamers containing eight-channel acoustic sensors that are towed behind a research vessel. When an acoustic signal from a compressed air source is deployed, changes in the speed of the sound returning to the dense array of sensors

are converted to a very fine scale 3D model of the geology beneath the seafloor.

The survey was conducted offshore from the industrial port of Tomakomai, the site of an extensive CO₂ capture, transport, and injection demonstration project. At the time of the survey, approximately 65,000 tons of CO₂ had been injected into a geologic formation 1,100 m below the seafloor. The ultimate goal of the project is to store 100,000 tons of CO₂ per year.

The surveys conducted in 2017 were the first to attempt high-resolution subsurface imaging at an active offshore CO₂ demonstration project. Obtaining such information reduces the risk of leakage and could provide an estimate of the volume of CO₂ stored in the reservoir. Meckel notes that the technology is suitable for deployment at other offshore sequestration sites, including sites located in the Gulf of Mexico.

For information, please contact Meckel at tip.meckel@beg.utexas.edu.



A compressed air acoustic source deployed at the Tomakomai CO₂ storage demonstration project in Hokkaido, Japan.



International Initiatives

Partnering Across the Globe

The Bureau of Economic Geology conducts research and establishes partnerships around the world. From the Arctic to Australia, Bureau researchers travel to wherever the science leads. In 2017, the Bureau continued to enhance its broad international presence.

In January, the Bureau hosted a group of twelve researchers and managers from Statoil, Norway's national energy company, for its inaugural professional-development training course. The week-long series of highly interactive presentations and activities exposed the rising stars from Statoil to a broad range of Bureau research and industry-engagement efforts.

For over a decade, the Bureau has worked diligently to establish productive relationships with industry and academics in China. In August, the Bureau hosted a delegation from China—including leaders from the country's environmental regulatory authority, the Chinese Assessment Center of Environment and Engineering—for a day of presentations and discussions about advancing China's fledgling shale-gas exploration industry and promoting that country's natural-gas production without overly restrictive environmental regulations.

Also in August, the Bureau cohosted a large delegation from Mexico for 2 days of discussions. Conducted in conjunction with UT Austin's

Department of Petroleum and Geosystems Engineering (PGE), the visit identified synergies between the new exploration initiatives of the government and energy industry of Mexico and the advanced energy research being conducted by the Bureau and PGE.

In October, Bureau director **Scott W. Tinker** and lead researchers **Julia Gale** and **Svetlana Ikonnikova** traveled to Qingdao, China, at the invitation of the president of the China University of Petroleum, geoscientist Dr. Fang Hao, and entered into a memorandum of understanding ensuring future collaboration between the two institutions on research into unconventional reservoirs and shales.



Bureau and China University of Petroleum delegates meet in Qingdao, China.



Near Surface Observatory Responding to Hurricane Harvey

Among the many capabilities of the Bureau of Economic Geology is the vital disaster-response capacity of the **Near Surface Observatory (NSO)** and its skillful team.

In August, Hurricane Harvey reached Category 4 status, bringing extreme winds, heavy rainfall, massive flooding, and moderate storm surge to the open coast and bays of Texas.

Within a week of landfall, researchers at the Near Surface Observatory began acquiring airborne lidar data and imagery to assess storm impacts on the beach and dune system along the Texas Gulf shoreline, identify debris and infrastructure damage in Texas bays, and establish a baseline for monitoring beach and dune recovery in the months and years to come. These surveys were flown

as part of the Texas General Land Office (GLO) comprehensive response to the ongoing effects of Hurricane Harvey.

To make data available to emergency responders as quickly as possible, the Bureau team developed an around-the-clock process to make data available to state agencies the day after it was acquired. **Aaron Averett** flew in the aircraft, handing data off to **John Hupp** for processing at the end of each flight day. Hupp then passed the data to **John Andrews**, who created preliminary digital elevation models and georeferenced aerial photographs, all of which were then uploaded to GLO to support its emergency response. **Tiffany Caudle** served as liaison with the Texas Department of Transportation for aircraft usage and verified data quality and coverage before delivery. **Kutalmis Saylam** deployed GPS base stations in some of the most storm-ravaged areas on the Central Texas coast. **Julie Duiker** and her team worked with GLO and UT Austin to ensure contractual requirements were met in record time. **Jeffrey G. Paine** (jeff.paine@beg.utexas.edu) served as principal investigator.



Aerial image taken from survey aircraft of extensive damage to Rockport, Texas, by Hurricane Harvey.



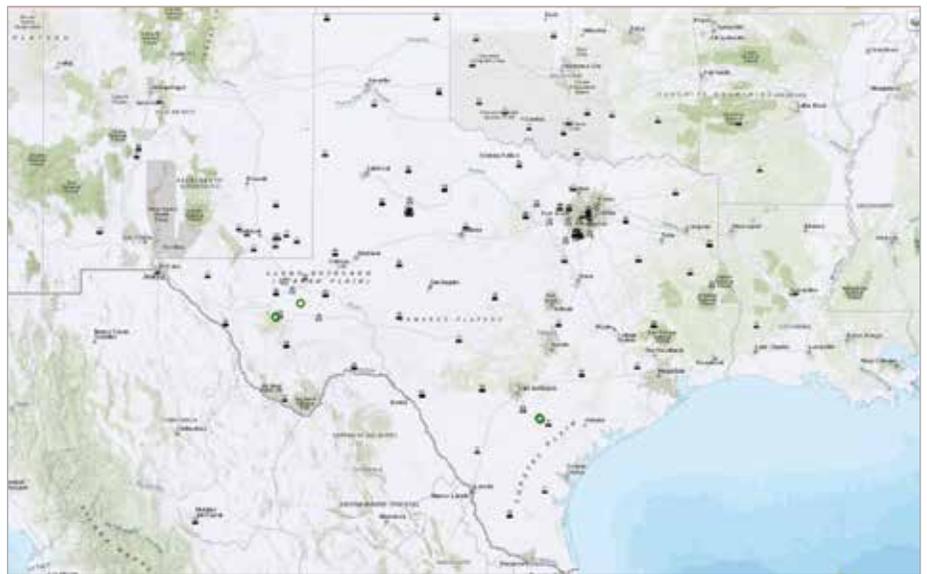
TexNet

Tracking Tremors Across Texas

Trusted for the validity of its wide-ranging research and its broad capacity to undertake and successfully coordinate significant, multi-faceted initiatives, the Bureau of Economic Geology was authorized by the Texas governor and the state legislature to deploy and operate TexNet, the most advanced state-run seismic-monitoring system in the country.

In 2017, the Bureau finished installing TexNet and now, thanks to a new interactive website, the public can follow and sort Texas seismic activity in real time.

TexNet includes 22 permanent monitoring stations, which brings the state's total number of permanent seismic stations to 40. A team led by Bureau research scientist **Alexandros Savvaidis** managed the design, installation, and testing of the statewide network. The system also includes 40 portable seismic stations that are being used to increase the density of stations in areas with recent increased seismicity, such as the Dallas–Fort Worth area, South Texas, the Delaware Basin, and the Snyder area of West Texas. These portable stations allow for detailed



The TexNet Earthquake Catalog allows users to view and filter seismic data collected by the TexNet earthquake monitoring system.

examination of the location, depth, size, and frequency of earthquakes so scientists and engineers can better assess their causes.

The seismic-monitoring system is being operated in parallel with the **Center for Integrated Seismicity Research** (CISR), a multidisciplinary research team led by Bureau research scientists **Peter Hennings** and **Ellen Rathje**. CISR conducts fundamental research to better understand natural and induced earthquakes in Texas.

“Governor Abbott and the Legislature have put Texas at the forefront of

data collection and research into the causes of seismicity in the state,” said Bureau director **Scott W. Tinker**, who led the formation of TexNet in 2015. “Small earthquake events have become more common in Texas recently, and we are now positioned to learn more about them and, hopefully, to understand how to mitigate their impacts in the future.”

For more information on TexNet and CISR, and to view the interactive web page, visit www.beg.utexas.edu/texnet or contact alexandros.savvaidis@beg.utexas.edu.



Unconventional Reservoirs Research Lending Expertise to Unconventionals

The Bureau of Economic Geology has supported the energy industry with a wide range of research for decades. So, it was only natural that when the “shale revolution” spread to source-rock basins across the country, the Bureau responded to the new technology and new scientific questions of operators by bringing together multidisciplinary teams to research the quandaries and the potential of these unconventional reservoirs.

Respected and often-cited Bureau studies have used an integrated approach when looking at the production and reserve capacity of four of the largest shale-gas basins and two of the largest shale-oil

basins in the U.S. Such an approach brings together geologic analysis, well-decline analysis, recovery and productivity statistical analysis, and well economics to project production outlooks using a multiscenario model. New data builds evolving 3D models of select basins.

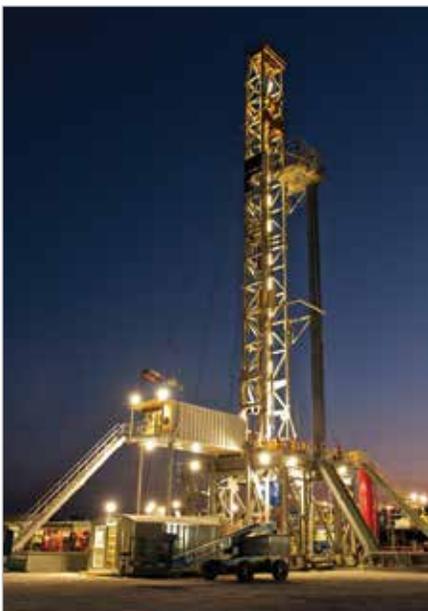
In 2017, the shale study team focused on extensive research within the **Tight Oil Resource Assessment (TORA)** consortium, assessing the production and reserve capacity of the complex multilayered and heterogeneous tight formations of the Permian Basin. 2017 also saw the launch of the **3D Resource Reserve and Production (3DRP)** consortium, an initiative set up to keep the original integrated, granular shale-basin studies continually updated.

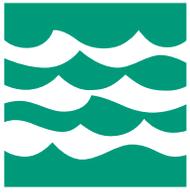
Many long-running research initiatives of the Bureau have uniquely experienced researchers who share information and answer questions about unconventional reservoirs. Among these is the **Mudrock Systems Research Laboratory (MSRL)**, which conducts integrated, multiscale, and multidisciplinary research in mudrock systems, and the **Reservoir Characterization Research Laboratory (RCRL)**, which uses outcrop and subsurface geologic

and petrophysical data from carbonate reservoir strata for developing new and integrated methodologies for better understanding and describing the 3D reservoir environment.

Shell-UT Unconventional Research (SUTUR) is a strategic collaboration to improve the efficiency, effectiveness, and sustainability of the exploration, development, and production of unconventional oil and gas resources through applied research. The collaborative effort brings together researchers from the Bureau of Economic Geology and Department of Geological Sciences at the Jackson School of Geosciences, from UT's Center for Petroleum and Geosystems Engineering (CPGE) at the Cockrell School of Engineering, and from Shell R&D teams to address critical problems in unconventional oil and gas. SUTUR II, which commenced in 2016, is an integrated study of the geologic origin of water produced from the oil-bearing shales of the Delaware Basin in West Texas.

For more information about the Bureau's extensive capabilities in unconventional reservoirs research and how you can benefit from them, please contact Associate Director for Energy Research **Mark Shuster** at mark.shuster@beg.utexas.edu.





Water–Energy Nexus

Leading Water-Use Studies

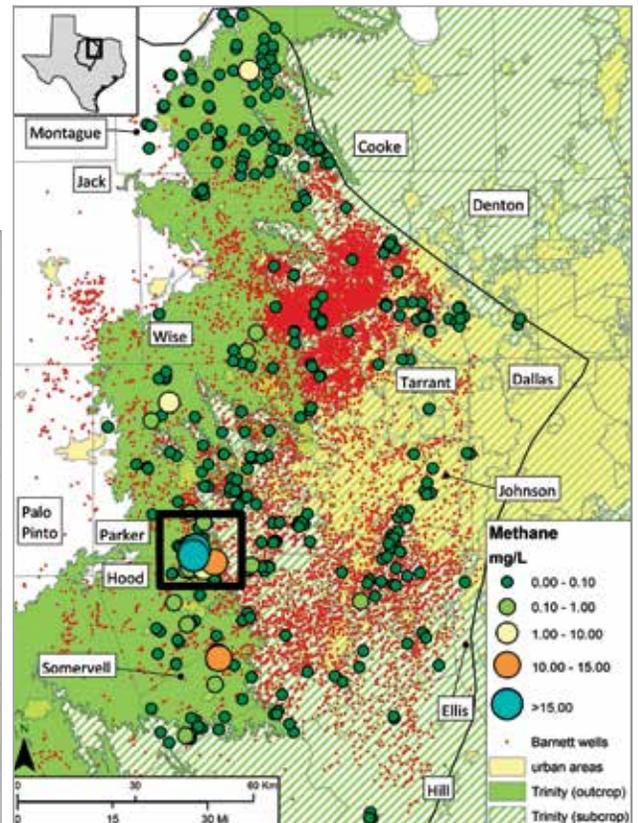
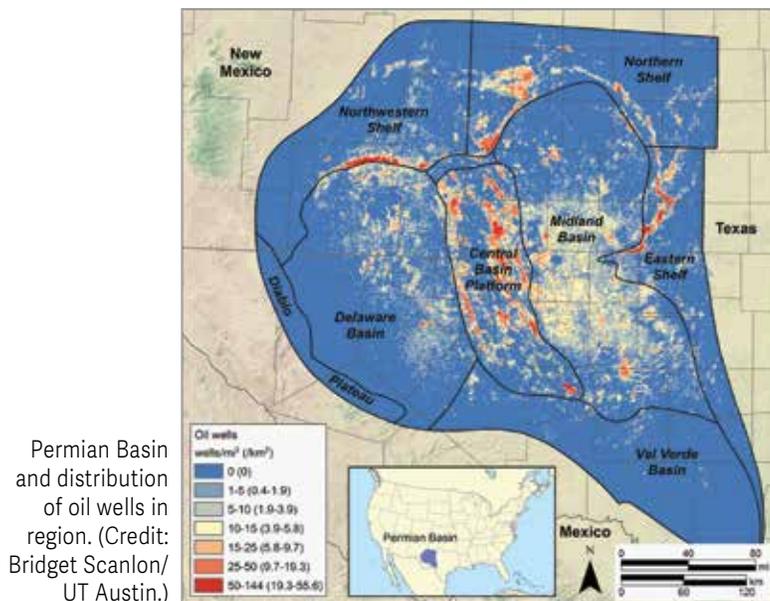
Bureau of Economic Geology studies range across the broad spectrum of energy, environmental, and energy-economics research. Among the Bureau’s most important areas of study over the past decade have been the interplay between water utilization and energy production, dubbed by some the “**Water–Energy Nexus**.” Research into this intersection between water and energy resources is vital because both are important for healthy economies and societies. Understanding these connections is also imperative as population grows and these resources become more complicated to manage and utilize.

Among the research completed in 2017 was a study led by Bureau senior research scientist **J.-P. Nicot** that found that high levels of methane in well water from two counties near Fort Worth are probably from shallow natural-gas deposits and not natural-gas leaks caused by hydraulic-fracturing operations in the underlying Barnett Shale.

Another widely read 2017 study conducted by Bureau researchers

Bridget Scanlon, Robert Reedy, Frank Male, and Mark Walsh highlights key differences in water use between conventional oil and gas drill sites and “unconventional” sites that use hydraulic fracturing, a practice that is rapidly expanding in the Permian Basin. Results of this study indicate that recycling water produced during operations at hydraulic-fracturing sites could help reduce potential problems associated with the technology.

Distribution of dissolved methane across the Barnett Shale play (457 groundwater wells). Numerous small red dots represent gas wells. (Credit: J.-P. Nicot/UT Austin.)



Research Consortia

3D Resource Reserve and Production

The Bureau is pleased to announce the launch of its newest consortium: **3D Resource Reserve and Production (3DRP)**. The Bureau leads the world in basin-scale resource characterization and production modeling, and membership in 3DRP gives you first access to integrated, granular, and updatable models for the major shale oil and gas plays in the United States, including the Marcellus, Haynesville, Barnett, Fayetteville, Bakken, and Eagle Ford.

Benefits included high-resolution 3D geomodels (original gas-in-place and oil-in-place, nonbound water-in-place, and derivative maps); statistical estimates of per-well productivity; well economics incorporating decline analysis; and production-outlook and expected-drilling scenarios.

3DRP models—originally developed with multi-million-dollar grants from the Sloan and Mitchell Foundations, State of Texas, and U.S. Department of Energy—will be updated by a team of geoscientists, petrophysicists, hydrologists, physicists, engineers, statisticians, and economists. This extensively published research helps the group educate the public and inform the decisions of state, federal, industry, and financial stakeholders. Original and future research integrates academic approaches and industry expertise to address important questions raised by key stakeholders both in the U.S. and globally.

Principal Investigator: Svetlana Ikonnikova
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Advanced Energy Consortium

The internationally recognized **Advanced Energy Consortium (AEC)** is dedicated primarily to achieving a transformational understanding of subsurface oil and natural gas reservoirs through the deployment of unique micro- and nanosensors. However, given the ongoing push toward reducing carbon-dioxide emissions into the atmosphere, the technology developed by the AEC is proving to have a much broader potential application portfolio. Areas of clear potential include hot dry rock (HDR) geothermal; seal integrity and other applications for measurement, monitoring, and verification (MMV) in carbon capture and storage (CCS); mining applications; cement integrity in nuclear waste; and nuclear-power generation.

Founded in 2008, the vision of the AEC is to illuminate oil and gas reservoirs and improve hydrocarbon recovery with novel micro- and nanosensing technology developed collaboratively with the global research community and our members. The AEC has invested more than \$50 million in research, with a combined 30 university and research facilities around the world. Since inception, the AEC has progressed from fundamental research to applied research targeting commercial applications (“use cases”) that will help members enhance their commercial extraction of oil and natural gas.

In only 9 years, the progress of the consortium has been remarkable. The AEC has created a whole new scientific space, published hundreds of peer-reviewed papers, created a patent portfolio exceeding 40 inventions, and is now on the verge of completing commercial-scale proof-of-concept tests. The AEC anticipates the generation of real commercial products in the next 12–24 months, as well as the initiation of new areas of research.

Principal Investigators:
Scott W. Tinker and **Jay Kipper**
(jay.kipper@beg.utexas.edu)



Applied Geodynamics Laboratory

The **Applied Geodynamics Laboratory (AGL)** is dedicated to producing innovative new concepts in salt tectonics. The AGL attempts to understand salt tectonics using three complementary approaches, which work together to build our understanding of salt deformation. The first approach involves kinematic and stratigraphic analysis of salt structures in some of the world's most spectacular salt basins. The second approach utilizes physical models to study the processes by which salt structures form and how these structures are affected by changing conditions. The third approach uses finite-element models to study the influence that salt movement has on stresses and fluid pressures in surrounding sediments.

Research results for 2017 include a comparison of salt tectonics in the eastern and western Gulf of Mexico, the differences explained as a consequence of rift geometries. Seismic interpretation in the northern Gulf of Mexico led to advances in understanding of minibasin fill and the evolution of Mesozoic allochthons at the downdip end of the basin. Other seismic-interpretation projects investigated shale diapirism in the western Mediterranean and strike-slip salt tectonics in China. Physical modeling successfully simulated evolution of the Salina del Bravo (western Gulf of Mexico), providing a mechanical explanation for the structures there. Other physical models showed structures formed by inversion of salt-bearing rifts, as well as progradation across such rifts. Finite-element modeling investigated heat flow around salt structures, the role of sand layers in controlling overpressure near salt, geomechanical evolution of material caught in salt-sheet sutures, and behavior of salt basins during continental separation.

Principal Investigator: Mike Hudec
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Center for Energy Economics

The **Center for Energy Economics (CEE)** performs research and provides training and outreach on energy-value-chain economics, markets, and frameworks for commercial and strategic investment.

Research highlights for 2017 include the CEE's annual update of producer financial data, which showed the continuing trend of negative cash flows for the group of 16 shale-heavy producers. Capital market access for upstream onshore plays will be a focus of research for 2018.

The CEE monitors and evaluates many energy- and environmental-policy developments that can impact assumptions regarding the price of natural gas, renewables expansion, and coal and nuclear retirements. Depending on these assumptions, 2017 dispatch modeling of the U.S. national grid yields a range of 23 billion cubic feet per day in 2030 for gas burn in power generation. An in-depth 2017 look at system-integration costs for wind and solar indicated that simple leveled costs of electricity comparisons are misleading; fully loaded wind and solar costs can beat those of a combined-cycle gas plant only in the best locations and with natural-gas prices that are much higher than the 2011–17 average, even when including cost of emissions. CEE also completed work on a U.S. Department of State Bureau of Energy Resources upstream oil and gas technical-assistance grant in Mexico, collaborating to share best-practice approaches across oil and gas value chains.

The Center is externally funded through research grants and contracts, corporate and government partnerships at the federal and state levels, and executive education programs through UT's McCombs School of Business. For more information, visit the CEE Think Corner: <http://www.beg.utexas.edu/energyecon/think-corner>.

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Center for Integrated Seismicity Research

The **Center for Integrated Seismicity Research (CISR)** hosts a multidisciplinary, intercollegiate research consortium that—together with **TexNet** and its state-funded network of seismometers across Texas—focuses on the integrated study of seismicity within the state and potential applications beyond. CISR's research thrusts are designed to understand the subsurface processes that may influence seismicity, and to quantify and reduce risk to the citizens and infrastructure of Texas. The CISR research team spans six University of Texas System units, as well as Southern Methodist University, Texas A&M University, Sam Houston State University, and Stanford University.

Currently there are seven major TexNet–CISR initiatives: maintaining and optimizing TexNet's 22 permanent and 40 portable stations across Texas; analyzing, cataloging, and disseminating earthquake data; characterizing historical and current seismicity; characterizing reservoir mechanics of disposal intervals and fault-triggering processes; understanding earthquake hazards and risk in Texas; conducting studies of earthquake social science; and coordinating seismicity monitoring and related research activities in the south-central U.S. multistate region.

Among CISR accomplishments in 2017 was the launch of the **TexNet Earthquake Catalog**, a dynamic mapping web page that provides information on the location of monitoring stations and recorded earthquakes across the state for use by the public, regulators, energy industry, and researchers. Studies of seismicity in the Fort Worth Basin reached interim conclusion with new models of the disposal stratigraphy, stress state, fluid injection characteristics, mapping and identification of faults of concern, and earthquake triggering mechanisms. A first look at seismicity in West Texas was also completed.

Principal Investigators:

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and **Alexandros Savvaidis**

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Deep Reservoir Quality Gulf of Mexico

The goal of the **Deep Reservoir Quality Gulf of Mexico** project is to decrease reservoir risk for deep to ultra-deep drilling in the Gulf of Mexico (GOM) by providing concepts and assembling data that can be used to forecast reservoir quality and stratigraphic architecture in deep prospects. This multidisciplinary study includes interpretation of depositional environment and sequence-stratigraphic framework, petrographic analysis of rock samples, statistical analysis of porosity/permeability relationships to controlling parameters, and burial-history modeling of key wells.

The focus of research in 2017 was the study of depositional and diagenetic controls on reservoir quality in deepwater Wilcox sandstones deposited in the Lavaca submarine canyon and the comparison of these to fluvial and shallow-marine sandstones deposited adjacent to Lavaca Canyon. The group also evaluated reservoir quality in deeply buried Wilcox sandstones in Brazoria County that were deposited within the transition from the outer slope to inner basin floor. Cores available from five wells in the Lower Wilcox in Lavaca Canyon display a variety of deepwater depositional environments and facies, including turbidite-channel fill, levee/overbank, and mass-transport deposits. Description and interpretation of these deepwater facies provided the context for understanding variation in reservoir quality caused by differences in grain size, sorting, matrix, silt, ductile-grain content, and diagenesis.

Lavaca Canyon sandstones are good analogs for deepwater Wilcox sandstones in the Gulf of Mexico because they have similar composition, reservoir quality, and thermal maturity. Reservoir quality in both the Lavaca Canyon Wilcox sandstones and in deepwater Gulf of Mexico Wilcox reservoirs is highly influenced by depositional processes and energy, by compaction, and, to a lesser extent, by cementation.

Principal Investigator: Shirley Dutton

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**DEEP RESERVOIR
QUALITY CONSORTIUM**

Fracture Research and Application Consortium

The **Fracture Research and Application Consortium (FRAC)** conducts basic and applied research leading to accurate characterization and prediction of natural fractures in the subsurface, and to a better understanding of how these fractures influence production operations, including their interaction with hydraulic fractures. Established in 1998, FRAC works with companies engaged in fractured reservoirs, unconventional in all rock types, and hydraulic-fracturing research ranging from physical and numerical experiments to the development of computer-modeling code.

Accurately predicting the attributes of natural and induced fractures is key to cost-effective resource extraction. FRAC uses a wide range of approaches, from subsurface analysis to outcrop studies; its diverse expertise includes engineering, geomechanics theory, rock testing and modeling, structural geology, advanced microstructural imaging, diagenetic characterization, and diagenetic modeling. The integrated structural-diagenesis approach to fracture and fault analysis began within FRAC.

Highlights in 2017 include advances in combining rigorous mechanics and geochemistry to understand the feedbacks in natural fracture growth, and incorporation of these effects into geomechanical models. Development and testing of these models in collaboration with member companies leads to more-accurate and testable pre-drill fracture predictions. Another area of progress was development of breakthrough analytical approaches to quantify fracture size distributions and spatial arrangements. The new approach to analysis of spatial organization was published in 2017, and the associated software is expected to be of great use in reducing costs and uncertainty in horizontal-drilling operations.

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FRAC FRACTURE RESEARCH & APPLICATION CONSORTIUM

Gulf Coast Carbon Center

The **Gulf Coast Carbon Center (GCCC)** is an industry-academic partnership conducting research on mitigation of industrial CO₂ emissions by the process of carbon capture and geologic storage. Key areas of research include selecting suitable subsurface settings for large-volume storage and providing assurance that storage is effective. The GCCC develops practical and informative assessments using numerical models, laboratory studies, and small- and large-scale field studies.

Recent GCCC progress ranges from very technical to highly policy relevant. Work on small-scale physical and numerical models is needed to assess initial saturation in order to more accurately assess storage capacity and allocate residual trapping, which improves upscaling and constrains CO₂ migration rates. In an attractive initial step of carbon capture, use, and storage, assessment of life-cycle carbon balance of CO₂ enhanced oil recovery (EOR) projects based on calibrated models of two sites shows the key role played by operator choices in the carbon storage value. Two conceptual improvements in monitoring are a new focus on signal attribution and a methodology for assessment of low-probability material impacts (ALPMI), a proactive method of forward-modeling risks to optimize monitoring.

A major current initiative considers technical, regulatory, and economic pathways for developing volumetrically significant and high-value storage in near-offshore environments. Highlighted activities include developing projects along the Gulf Coast, a collaboration with a unique offshore project in Japan, and successful global networking. The group continues its monitoring at major commercial storage sites.

Principal Investigator: Susan Hovorka
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Mudrock Systems Research Laboratory

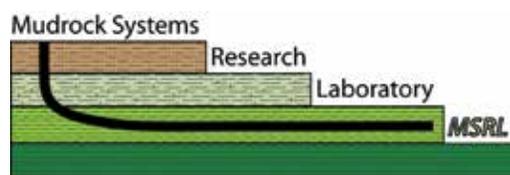
The **Mudrock Systems Research Laboratory** (MSRL) continues to focus on defining the interrelationships among rock and fluid attributes in mudrock systems. The Eagle Ford Group remains an area of research interest; the MSRL integrates multiscale (subpore to interwell) data from the Eagle Ford, including detailed studies of horizontal core, to construct a geologic model that can be used to examine variations and importance of such key attributes as bed continuity, fluid flow, pore types and distribution, rock strength, and saturation.

New areas of research include the Wolfcamp/Bone Spring section of the Delaware Basin, where the MSRL has assembled a suite of 20 cored wells and is conducting multidisciplinary analyses to define rock/fluid attribute variations at local and regional scales.

MSRL research on the Eagle Ford reservoir system is expanding into secondary targets of the upper Eagle Ford, Austin, and Buda to determine the relative importance of in situ versus migration-related hydrocarbon-charge pathways and the relationship pore systems and mineralogy have to these variations. Associated with this effort is upcoming study of new, immature Eagle Ford cores for information about original kerogen distribution and porosity and organic-matter evolution in the interrelated systems.

The MSRL continues to experiment with varying techniques for obtaining accurate multiscale measurements of petrophysical properties, including relative permeability, in the Eagle Ford and other mudrock formations. Also underway are efforts to apply in situ dynamic micro-CT scanning to investigate fluid movement in mudrocks for a better understanding of multiphase flow and fluid distribution and their interrelationships with mineralogy.

Principal Investigator: Steve Ruppel
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Quantitative Clastics Laboratory

The **Quantitative Clastics Laboratory** (QCL) is a Bureau industry research collaboration focused on the sedimentology and stratigraphy of clastic depositional systems, with applications in reservoir modeling, uncertainty in subsurface stratigraphic correlation, and source-to-sink predictions for frontier exploration. Researchers use outcrop, subsurface, and Earth-surface data to investigate the processes and products of fluvial, shallow-marine, and deepwater depositional systems, with the aim of determining the impact of realistic modeling of reservoir architecture and facies distribution on reservoir performance of these systems. To predict reservoir presence and quality, researchers also use multi-proxy provenance analysis to understand external drivers and paleogeography of sediment source areas, drainage networks, and depositional systems.

Sponsorship of the QCL grew during 2017, and the research team continues to enlarge its sphere of influence by presenting at international geoscience conferences and universities, and publishing peer-reviewed research in high-impact geoscience journals. The diverse QCL team expanded in 2017 with the hire of new research scientist **Zoltan Sylvester**, who is a former oil and gas industry expert in clastic sedimentology and seismic stratigraphy, as well as a world-class stratigraphic/reservoir modeler.

Sponsors of the consortium—which predominantly comprises oil and gas companies, as well as government institutions such as the U.S. Bureau of Ocean Energy Management—can expect a comprehensive approach as the QCL research team carries out integrated geologic studies at multiple scales to develop models for processes and controls on sediment transport and the stratigraphic evolution of depositional systems.

Principal Investigator: Jacob Covault
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Reservoir Characterization Research Laboratory

A hallmark of the **Reservoir Characterization Research Laboratory** (RCRL) program is its recognition of subsurface-characterization challenges that can be enhanced by the use of well-defined outcrop analogs, uniquely combined with a breadth of subsurface-characterization experience applied to problems important to sponsors of the program. In its 30 years of research on carbonate systems, the RCRL has developed techniques that populate the carbonate sequence-stratigraphic framework with reservoir-flow properties to improve hydrocarbon recovery.

Yet many challenges still exist within carbonate reservoirs, especially in the areas of integration of nonmatrix pore systems, pore-network-related diagenesis, and the realistic 3D variability of lithofacies distribution. The 2018 RCRL research program will cover multiple investigations and themes such as (1) platform-scale stratigraphy, (2) reservoir architecture and intra-play evolution, (3) structural and geomechanical characterization, (4) pore-network characterization, and (5) geochemical and chemostratigraphic analysis of carbonate systems.

One example of RCRL research is the role that older Paleozoic structures play both in controlling deformation styles and in the development and fracture intensity of the overlying younger Mesozoic carbonate strata. This concept—with its important implications in deciphering the role of early tectonic history on later fluid migration and potential hydrocarbon production—will form the basis for defining optimal drilling direction for unconventional resources. Another RCRL study utilizes an extensive regional seismic dataset of 2D and 3D lines to highlight the strike variability of Tertiary carbonate-platform architecture along strike of the North West Shelf of Australia. This investigation aids the development of regional-scale principles of carbonate stratigraphic architecture.

Principal Investigators:

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Robert G. Loucks (bob.loucks@beg.utexas.edu)



State of Texas Advanced Resource Recovery Program

The goal of the **State of Texas Advanced Oil and Gas Resource Recovery** (STARR) program is to increase royalty- and severance-tax income to the state from oil and gas production in Texas. Significant oil and gas production comes from unconventional shale plays in Texas, including the Eagle Ford and Wolfberry trends, which the STARR program has characterized for the state.

In the 2014–16 biennium, STARR added approximately \$54 million to the state's Permanent School Fund and General Revenue Fund from royalties and severance taxes from increased production. This revenue was the result of a wide variety of recent regional- and reservoir-characterization studies that include the Spraberry and Wolfcamp Formations in the Permian Basin, the Eagle Ford Trend in South Texas, the Eaglebine Trend in southeast Texas, Permian and Pennsylvanian reservoirs in the Eastern Shelf of the Permian Basin, the Wilcox Group in the Texas Gulf Coast, and Pennsylvanian-age reservoirs in the Texas Panhandle.

In the past 2 years, more than 20 oil and gas companies have participated in STARR integrated studies of important oil and gas plays. Many of the studies have been presented recently in workshops that provide up-to-date results and are a valuable resource for operators and explorationists in Texas. To date, the STARR program has generated more than 60 field studies. More than 50 Texas oil and gas operators have been involved in the STARR program over the project's 25-year duration. STARR studies have been used to recommend more than 300 infill and step-out wells, as well as many recompletions in a wide variety of oil and gas fields across the state.

Principal Investigator: Bill Ambrose
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Principal Investigator: Bill Ambrose
(william.ambrose@beg.utexas.edu)



Texas Consortium for Computational Seismology

The **Texas Consortium for Computational Seismology (TCCS)** is a joint multidisciplinary project of the Bureau of Economic Geology and the Institute for Computational Engineering and Sciences (ICES). TCCS is focused on (1) addressing the most important and challenging research problems in computational geophysics as experienced by the energy industry, and (2) educating the next generation of research geophysicists and computational scientists. TCCS research, combining expertise in geophysics and applied mathematics, concentrates on such areas of seismic-data analysis as elastic reverse-time migration, full waveform inversion, automated seismic interpretation, time-lapse seismic-image registration, seismic-diffraction imaging, and seismic anisotropy. For computational experiments, TCCS develops open-source software tools and utilizes supercomputing resources provided by the Bureau and the Texas Advanced Computing Center (TACC). Results are provided to the sponsors in a reproducible form.

Among TCCS research accomplishments in 2017 were the development of a new method for extracting fault surfaces; the application of predictive painting to pick residual moveouts in common image gathers (CIGs), using pattern information of CIG events as a guide to avoid picking aliased events; a semiautomatic method to efficiently and consistently tie available well-log data to seismic; and the application of a modified image-guided well-log interpolation method for initial subsurface model construction. Also in 2017, TCCS postdoc **Xinming Wu** received the 2016 Best Paper Award in Geophysics for co-authoring “3D Seismic Image Processing for Faults.”

Principal Investigator: Sergey Fomel
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Tight Oil Resource Assessment

The **Tight Oil Resource Assessment (TORA)** project, which began in July 2016, has built upon the exemplary research of the Bureau’s national Shale Production and Reserves Study to analyze the complex oil-rich source rocks of the Midland and Delaware Basins of the Permian Basin. TORA has adapted this study’s workflow to help predict ultimate hydrocarbon recoveries, economic viability, and play-wide production rates. The project is in the process of addressing the main tight-oil formations of the Permian Basin: the Spraberry, Wolfcamp, and Bone Spring.

TORA has brought together an integrated, multi-disciplinary team—including geologists, petroleum engineers, petrophysicists, economists, hydrologists, and GIS/database experts—from across UT Austin and beyond, employing a multifaceted approach to analysis of a wide variety of challenging subject areas, including geology and petrophysics, reservoir engineering, energy economics, and water-resource management.

TORA employs a bottom-up approach that starts with detailed geologic mapping and a well-by-well production analysis. Much of the Permian Basin mapping was completed in 2017. Future production outlooks will depend on economic considerations, including various price, cost, and technology-improvement scenarios. Water resources utilized in drilling and production operations and/or produced from the Permian Basin formations are also being thoroughly studied.

An integral part of TORA workflow is 3D geomodeling. Separate billion-cell geomodels of the Midland and Delaware Basins have been created, providing extraordinary geologic insight.

TORA sponsorship grew significantly in 2017. Many of the top tight-oil operators are sponsors, including the two most active operators in the basin. TORA held two industry sponsor meetings in 2017.

Principal Investigators:
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and **Svetlana Ikonnikova**
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Events

Bureau Breaks Ground on New Core Research Building



From left to right: Jackson School of Geosciences dean Sharon Mosher, Kenneth Edwards (BEG), Bureau assistant director Jay Kipper, Kim LaValley (BEG), Dr. Robert Loucks (BEG), Bureau director Scott W. Tinker, Mark Blount (BEG), Bureau assistant director Michael Young, Scott Mokry (UT architect and project manager), Chris Zahm (BEG), Bureau assistant director Mark Shuster, Toby Smith (Flintco project manager), and Lauren Alexander (Atkins architect).

On October 5, the Bureau began construction on its new core research building, a project that will provide advanced facilities for scientists conducting research on cuttings and core samples in the Bureau's Austin Core Research Center.

"Everything we do is built on rocks," said Bureau director **Scott W. Tinker** during the groundbreaking ceremony. "It's exciting to have this new building to show what we're all about."

The Bureau, which also acts as the State Geological Survey of Texas, has the largest collection of geologic material in the country in its three core repositories in Austin, Houston, and Midland. The repositories act as a "Library of Congress" for core samples, holding more than 2 million boxes of specimens. These cuttings and core samples are fundamental

for research in oil and gas, mineral, and geothermal exploration, as well as in hydrogeology and other fields.

Scientific equipment in the new facility will include a scanning electron microscope on a floating slab, a design that prevents vibrations from traffic on nearby roads from interfer-

ing with the delicate instrument. The 10,000-sq-ft building will also include a core viewing room exclusively for use by students and Bureau research staff. The roof of the building will include a terrace for events.

The new building, scheduled for completion by fall 2018, will be located adjacent to the Bureau's headquarters on The University of Texas at Austin J. J. Pickle Research Campus. After the new construction, the Bureau will begin major renovations on the building that serves as its current core research center, a project that should take 2 to 4 months. The plan is to update 17 labs with state-of-the-art equipment, as well as to update the building's interior design. In total, the new building and renovations will cost \$10 million and are phase one of a larger project, with phase two including the construction of a Texas rock garden between the old and new buildings.



Artist's rendering of the Bureau's state-of-the-art core research facilities.

Bureau Welcomes UT President Fennes

In September, UT Austin president **Gregory L. Fennes**, in his first visit to the Bureau, joined Bureau staff at their annual fiscal-year-end gathering.

Bureau director **Scott W. Tinker** opened the event by thanking President Fennes for his strong support during and following the 2017 session of the Texas Legislature.

Although some Bureau programs suffered major cuts in state funding during the session, President Fennes restored millions of dollars to those programs from the University's overall state appropriations.

Said Fennes, "The Bureau of Economic Geology is unique to the mission of the University. The work that you do has tremendous impact on the state."



Director Tinker (third from right) joins President Fennes (second from right) and Bureau staff in a horns-up tribute to the University.

DOE Grants Bureau \$4 Million for CCS

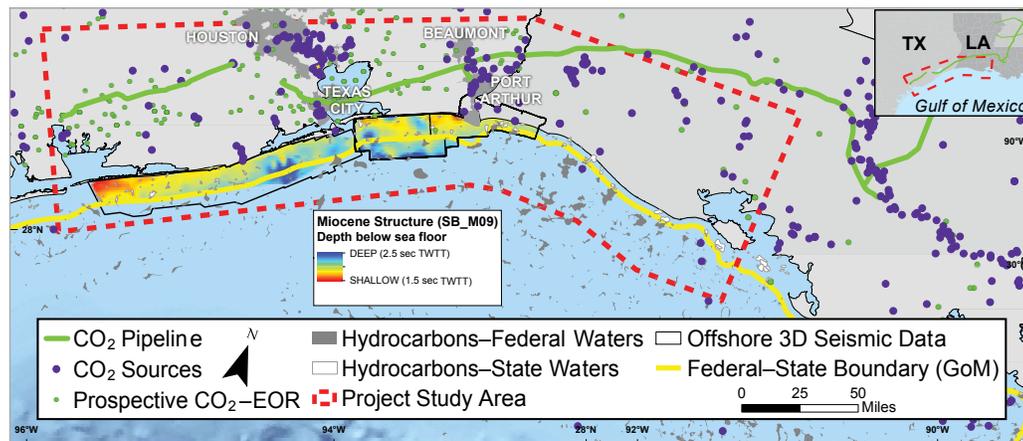
The U.S. Department of Energy has granted the Bureau \$4 million to lead a regional partnership to explore how carbon dioxide (CO₂) emitted from industrial facilities along the Gulf Coast can be safely stored in geologic formations under the Gulf of Mexico.

The 4-year program will be led by the Bureau's **Gulf Coast Carbon**

Center (GCCC) and include institutions and partners from UT Austin and throughout the nation. The goal of fostering safe, long-term storage of CO₂, a greenhouse gas that is linked to climate change, involves capturing CO₂ from industrial facilities, transporting it offshore, and injecting it into a geologic formation deep beneath the seabed,

where it would remain safely stored and isolated from the ocean water.

"This is the type of science that aims at tackling big issues by bringing government, industry, community stakeholders, and academia together to create innovative solutions. It builds on the work our GCCC has been doing the past 15 years in sequestration," said Bureau director **Scott W. Tinker**.



Map identifying opportunities for CO₂ hub development in southeast Texas incorporating offshore storage.

The partnership's mission includes researchers from UT Austin's Institute for Geophysics (UTIG) and Cockrell School of Engineering, U.S. Geological Survey, Louisiana Geological Survey, Lawrence Berkeley National Laboratory, Lawrence Livermore National Laboratory, Lamar University, and Trimeric Corporation.

GCCC Hosts CO₂ Events in Southeast Texas

In June, the Bureau's **Gulf Coast Carbon Center** (GCCC) hosted three events in the Beaumont–Port Arthur area to consider both local and global opportunities to capture, transport, and store CO₂ in deep geologic formations beneath the Gulf of Mexico.

The second **International Workshop on Offshore Geologic CO₂ Storage**, facilitated by the Bureau's **Katherine Romanak** and Tim Dixon from the International Energy Agency Greenhouse Gas (IEAGHG) R&D Programme, was held at the Center for Innovation, Commercialization and Entrepreneurship at Lamar University in Beaumont and featured presentations, posters, and discussion by researchers, project developers, and regulators from China, South Africa, Japan, Norway, France, the Netherlands, the UK, Canada,

and across the United States. The Carbon Sequestration Leadership Forum (CSLF) supported travel for several key participants.

Tip Meckel of the Bureau led a field trip highlighting potential CO₂ point sources in the Port Arthur industrial corridor, CO₂ transportation options, and the highly favorable geology in this region. The thick Miocene sandstones beneath state-owned submerged lands in near-offshore Texas provide a high-quality and exceptionally well-known resource for CO₂ storage that has been the topic of Bureau investigations for decades, resulting in significant publications and recent major geologic storage-focused research (**Texas Offshore Miocene Project**, **TXLA Offshore CO₂ Storage Resource Assessment**, **The Search for CO₂ Storage**). The

trip included visits to GT OmniPort and Air Products facilities.

Events concluded with a workshop and open house, hosted by Lamar University, to explore the connections and opportunities between carbon sources and sinks in the Gulf Coast, as part of the CarbonSAFE project. The project, supported by the U.S. Department of Energy, examines the implementation of carbon capture and storage technology in the Golden Triangle Area (Beaumont–Port Arthur–Orange) of southeast Texas.

The information and ideas shared during these events will hopefully lead to international collaboration on offshore CCS projects and, ultimately, stimulate implementation of CCS globally.



Participants at the International Workshop on Offshore Geologic CO₂ Storage at the new Center for Innovation, Commercialization and Entrepreneurship at Lamar University in Beaumont.

CEE Brings Together Energy Leaders

The **Center for Energy Economics** (CEE) serves a vital role in bringing together energy-thought leaders—educating stakeholders on energy economics and commercial frameworks using comparative research to facilitate energy development. In 2017, the CEE met with various energy regulators to analyze the direction of the group’s ongoing research into the market forces shaping global energy, and it began a collaboration with the Economic Minerals Program to study the underlying market fundamentals that affect minerals and mineral commodities.

Global Energy Strategy Meetings

In May, the CEE invited stakeholders and supporters of its new member-funded research consortium, the Electric Power Research Forum (EPRF), for a “think day” to analyze and discuss how the EPRF will analyze electricity markets. These complex markets are undergoing transformation as utilities and regulatory authorities weigh the impact of a broad



Gürcan Gülen

spectrum of issues ranging from decreasing government subsidies, distributed generation, electricity storage, and carbon pricing to a reliable power-supply mix that includes renewable sources. One potential research thrust discussed was cost-benefit analyses of various power-delivery options. (For more information about participating in the comprehensive efforts of the EPRF, please contact **Gürcan Gülen** at gurcan.gulen@beg.utexas.edu.

In June, the CEE hosted its 5th Mid-Year Meeting at its offices in Houston. A diverse group of experts presented information on some of the challenges and opportunities facing global energy industries. Natural-gas markets and related issues were explored in depth, as were retail electricity markets and a relatively new area for CEE research, the economics of mineral resources required in power-generation operations and equipment.

Since its founding in 1909, the Bureau has studied the economic viability of the extraction of minerals from Texas. Now, in conjunction with the CEE, the Bureau’s **Economic Minerals Program** will conduct research and publish its findings on minerals in specific energy-value-chain uses and their supply–demand dynamics. This new collaboration brings the

Economic Minerals Program



Sand-resource research leaders Brent Elliott of the Economic Minerals Program and Michelle Foss of the CEE.

Economic Minerals Program’s expertise in mineral geology and mining engineering together with the CEE’s expertise in mineral economics and commercial frameworks.

Said **Michelle Michot Foss**, CEE chief energy economist, “In order to fully evaluate the economics and viability of both conventional and alternative energy systems, it is vital that we understand the resource endowments and value-chain/supply-chain economics of critical minerals.”

Some of the key minerals being studied now include hydraulic-fracturing sand, lithium, cobalt, graphite, rare

earth elements, metallic ores, uranium, and aggregate resources. Areas of research will include geologic mapping, resource estimation, extraction and processing technology, commercial frameworks, value chains, international trade, extraction economics and industrial organization, and commercialization.

For more information on how you can be involved in this collaboration between CEE and the Economic Minerals Program, please contact **Brent Elliott** at brent.elliott@beg.utexas.edu.

Continued on page 21

A Closer Look at Sand Resources

One economically significant application of mineral resources studied by the CEE and Economic Minerals Program is the sand (proppant) used in fracking wells in the oil and gas industry. Fracking operations have seen a steady rise in the amount of sand used in each well, almost doubling in volume over the last 5 years. The United States produced 95 million metric tons of industrial sand in 2015, more than half of the global sand production; 71% of the U.S. tonnage was used as hydraulic fracturing sand and well-packing and cementing sand.

The Bureau is engaged in geologic mapping of sand resources, especially formations and units like the Hickory Sandstone of the Riley Formation that produce much of the traditional frac sand from Central Texas. Part of a sand-resource analysis includes the use of geospatial modeling techniques to map out the most favorable areas for exploration and resource extraction. Researchers determine where the sand is being transported, what kind of transportation infrastructure and possible pathways for transport (such as trucks or trains) exist, distances of quarry operations to metropolitan areas that may require more resources as population grows, and other characteristics like



Rounded, relatively uniform grains like these from the Kermit sand are desirable for applications like fracking.

resource quality and stripping ratio to build a combined map of new favorable sand-mining sites across Texas.

Because transportation costs make up a majority of the expense in distributing sand for quarry operations to consumer site locations, the Bureau also creates transportation models that integrate costs, distances, routing, trans-loading, and other important factors to generate network datasets for all modes of transportation infrastructure in Texas. These models allow researchers to identify new infrastruc-

ture development opportunities and predict the impact of new transport infrastructure like railroads, highways, and freight-transfer stations near mining sites and hydraulic fracturing sites.

With sand resources playing a significant role in the extraction of hydrocarbons from the prolific shale and tight oil formations of Texas and elsewhere in the U.S., sand research by the Bureau of Economic Geology will play an integral role in influencing the decisions of the American energy industry for many years to come.



A quarry in the Hickory Sandstone of the Riley Formation. (Photo by Rich Kyle; location courtesy of Proppant Specialists.)

Ikonnikova Presents Energy Webinar



Svetlana Ikonnikova

In July, Bureau research scientist and energy economist **Svetlana Ikonnikova** presented the webinar “Energy Forecasting: Shale Gas” with energy analyst John Staub of the U.S.

Energy Information Administration. Webcast by the AIChE Academy, the 1-hr talk covered key topics—especially the roles of technology, geology, and uncertainty in efforts to accurately forecast future shale production—that are central to Ikonnikova’s ongoing research as part of the Bureau’s comprehensive **Shale Production and Reserves Study**. Ikonnikova serves as co-PI of the program, among the most extensive integrated studies of shale production and economics in the United States to date, and has authored or co-authored numerous papers resulting from that research.

The Bureau program recently concluded a comprehensive study of the Bakken unconventional resource in North Dakota and Montana and reported summaries of its findings at the Unconventional Resources Technology Conference held in Austin in July.

The “**Energy Forecasting: Shale Gas**” **webinar** can be viewed at the AIChE Academy site, which provides a wide range of educational resources for topics such as energy, chemical and biological engineering, and sustainability and environment.

STARR Hosts Core Workshop

In October, the **State of Texas Advanced Resource Recovery (STARR)** program hosted a core workshop, “Shelf-to-Basin Architecture, Depositional Systems, and Facies Vari-

ability of the Southern Eastern Shelf of the Permian Basin,” featuring presentations by **Tucker F. Hentz, William A. Ambrose, Robert W. Baumgardner, and Fritz Palacios**. The event, sponsored by the Austin Geological Society, offered an in-depth overview of shelf, shelf-edge, and slope-depositional-facies characteristics; stratigraphic variations; and sedimentation trends across the southern Eastern Shelf and adjacent Midland Basin, a region that is currently the site of both conventional and unconventional exploration and production. For more information on the region, see the Bureau’s **Report of Investigations 282**.

The STARR program conducts geologic research that increases the production and profitability of oil and gas wells in the State of Texas. Since its inception in 1996, STARR has helped raise \$515.6 million in severance tax revenues, offsetting the program’s \$39.8 million funding investment, and has undertaken more than 60 field (reservoir characterization) and 15 regional studies. Over 50 Texas oil and gas operators participate in the program. Results of STARR regional studies are used by oil companies as the basic framework for their exploration efforts. Core workshops such as this one are a key component in the technology transfer process. To learn more about STARR and future workshops, please contact **William Ambrose** at william.ambrose@beg.utexas.edu.



William Ambrose (left) explains core samples to workshop attendees.

18th Annual Austin Earth Science Week Career Day

In October, the Bureau joined with area geoscience professionals to host the 18th Annual Austin Earth Science Week Career Day, which engages students in discovering earth sciences, encourages Earth stewardship, and motivates geoscientists to share their knowledge of and enthusiasm for our planet. Participants included 340 middle school students from Bastrop, Gorzycki, Ridgeview, and Bedichek middle schools, joined

by the Eco-Explorers and Austin Area Homeschool Science Team.

Students participated in presentations, demonstrations, and hands-on activities showcasing exploration geology, hydrology, seismology, geophysics, paleontology, geologic mapping, meteorology, planetary and solar system studies, gems and minerals, archeology, and engineering. The events were led by approximate-

ly 65 geoscience professionals from the U.S. Geological Survey, Texas Water Development Board, City of Austin, TxDOT, Lower Colorado River Authority, KOKE FM radio, Texas Commission on Environmental Quality, and others. Financial sponsors included Statoil (underwriting sponsor), Austin Geological Society, Parsley Energy, Schlumberger, and The Subsurface Library of Midland.



John Hash of the GeoFORCE program leads students through the Great Global Race activity.



Leyon Greene of the Texas Water Development Board demonstrates aspects of the TexMesonet program to students.



Statoil volunteer Codie Kretzer shows a middle-school student how to use a hand lens to examine a 3-billion-year-old rock.

5th Annual Bureau Research Symposium

In September, Bureau research scientists, postdoctoral researchers, graduate students, and support staff gathered for the 5th Annual Bureau Research Symposium, whose goal is to promote project collaborations and the interchange of ideas between researchers.

This year, the event showcased not only 32 posters illustrating research efforts but also a new format suggested by staff: short oral

presentations, or “nanotalks.” Staff voted on their favorite poster and nanotalk presentations: the nanotalk “Deepwater Channel Trajectory Controls on Reservoir Connectivity” by Ph.D. candidate **Paul Morris**, and the poster “Topographic Control on the Subsurface Heat Budget of Ice Wedge Polygons” by Ph.D. candidate **Chuck Abolt** and Associate Director **Michael Young**.



Dr. Ali Goudarzi explains his poster “Pressure Management and CO₂ Plume Control at the Devine Test Site, South Texas, by Means of Brine Extraction.”

Inaugural Statoil Fellows Poster Session

In the spring, Bureau graduate students **Ningjie Hu** and **Dmitrii Merzlikin** participated in the inaugural Statoil Fellows Poster Session hosted by the company at its headquarters in Austin. Statoil Fellows are graduate students whose proposals supporting research areas of importance to the company are selected in a competitive process for funding. Hu and Merzlikin

were among 13 Statoil Fellows from UT Austin's Jackson School of Geosciences (JSG) and the Cockrell School of Engineering who presented posters at the event, which provided an opportunity for executives and researchers of the company to meet and engage with their sponsored students. Statoil is an important partner of the Bureau in a number of its key research initiatives.

Hu's poster was entitled "Depositional Controls on Reservoir Quality of a Mixed Siliciclastic-Carbonate System, Lower Permian (Leonardian) Spraberry Formation, West Texas, USA"; his faculty advisors are Bureau research scientist **Jake Covault** and JSG's David Mohrig. Merzlikin's poster was entitled "Diffraction Imaging Using Azimuthal Plane-Wave Destruction"; his faculty advisor is Bureau research scientist **Sergey Fomel**.

Attendees at the inaugural Statoil Fellows Poster Session.
(Photo courtesy of Lorena Moscardelli.)



Explore UT: Discover What's Next



Luca Trevisan (lower right) and Jacob Anderson (upper right) explain carbon capture to Explore UT visitors.

In March, Bureau staff members and volunteers participated in the annual Explore UT campus-wide open house, which is designed to broaden the horizons of students in Texas and to motivate them to pursue further education after high school.

Senior Research Scientist **Sue Hovorka** led the "What to Do with CO₂: Cures for the Feverish

Earth" activity, which invited visitors to investigate how carbon dioxide emissions can be captured and stored through geologic sequestration. Bureau volunteers **Emily Beckham**, **Jacob Anderson**, **Naiara Fernandez**, and **Luca Trevisan** engaged visitors in experimenting with fire and ice to learn about carbon capture.

Research Scientists **Dallas Dunlap** and **John Andrews** presented children, teachers, and parents with "Exploring Earth's Natural Energy Resources with 3D Visualization," which explained how 3D technology and complex remote-sensing data sets allow geoscientists to harness energy sources while gaining greater understanding of our planet.



Dallas Dunlap (standing in left photo) and John Andrews (at left in right photo) prepare to show visitors a 3D presentation about energy resource exploration.

Industry Day 2017

In March, the Bureau hosted Industry Day 2017 at its **Houston Research Center**, where over 90 representatives from companies large and small attended the seminar featuring topics of current interest presented by the Bureau's top researchers.

Among the presentations were updates on the progress of the Bureau's renowned shale studies, including the **Tight Oil Resource Assessment (TORA)** project, its newest undertaking to understand the complex oil-producing formations of the Permian Basin. Also featured were a presentation on Bureau research into a novel tool to improve seismic imaging; a progress report on the status of the **TexNet** earthquake-monitoring network and its research arm, the **Center for Integrated**

Seismicity Research (CISR); and a lunchtime overview of research related to water issues in shale-formation production.

Bureau director **Scott W. Tinker** welcomed Industry Day guests

with an overview of the Bureau's major initiatives, stressing the vital importance and practicality of industry partnerships and of industry support for joint research projects.



Houston Research Center

Bureau Unveils New Texas GeoSigns

In April, Bureau information geologist **Linda Ruiz McCall** spoke to attendees at the unveiling of five new interpretive signs at the Goat Cave Karst Preserve in South Austin. The signs installed at the site encourage good stewardship of the land and explain the karst terrain, endangered species, and interaction between surface water and groundwater in the recharge zone of the Edwards Aquifer system. Project partners include the City of Austin, the Balcones Canyonlands Preserve, the Save Barton Creek Association, the Austin Parks Foundation, and many citizen volunteers.

The Goat Cave Karst Preserve signs are part of the broader **Texas GeoSign Project**, whose goal is to promote the understanding of geo-

This Goat Cave Karst Preserve GeoSign is an example of interpretive signs teaching about the geology and environment of selected sites around Texas.



logic information. McCall leads the project, which includes Bureau team members **Chock Woodruff, Cari Breton, Jamie Coggin, Cathy Brown, Amanda Masterson**, and

Jay Kipper. If you are interested in learning more about this initiative, please contact **Linda McCall** at linda.mccall@beg.texas.edu.

Educational Workshops and Training



Children at the 2017 Boy Scout STEMboree examine and identify rocks and minerals.

In 2017, Bureau research and support staff reached over 1,500 Texas K–16 educators and students, as well as members of community groups, with educational workshops, presentations, training, and field experiences focusing on the geology of the state and on the innovative research of the Bureau.

Outreach to K–12 teachers included training on the Balcones Fault Zone Aquifer, Texas industrial minerals, geologic maps and satellite imagery, and rocks and minerals. Educators were also informed about **EarthDate**, the Bureau's new public radio series, and **Texas Through Time**, the Bureau's recently released book about the geology of the state.

Outreach to K–12 students focused on careers in geoscience, rocks and minerals, earth processes, and research at the Bureau. Students from the **GeoFORCE** 12th-grade Summer Academy were given presentations and tours of the Austin Core Repository. Bureau geoscientists **Jeff Paine**, **Tiffany Caudle**, **Peter Flaig**, and **Linda Ruiz McCall** also served as instructors for the GeoFORCE

Summer Academy programs. In addition to in-person presentations, the Bureau's distance-learning outreach offered 150 5th-grade students from Austin Elementary School in Irving, Texas, a virtual field trip via the internet from Enchanted Rock to the Texas coast to learn about weathering and erosion.



Palacios High School advanced physics students collect beach-profile data from site MAT02 on Matagorda Peninsula.

The **Texas High School Coastal Monitoring Program** (THSCMP), which is led by **Tiffany Caudle**, marked its 20th anniversary in 2017. The THSCMP is a research and outreach project that engages students and teachers who live along the Gulf of Mexico in the study of their natural environment. Students collect data in a real-world setting that are used by working scientists to address coastal issues. A total of 294 data-collection field trips have been completed through this program to date.

In undergraduate outreach, students from San Angelo State

University toured the Austin Core Repository and listened to presentations from Bureau research and support staff including **Bill Ambrose**, **Tucker Hentz**, **Brent Elliott**, Robert Baumgardner, **Nathan Ivicic**, and **Linda Ruiz McCall**. Texas Association of Community College geology professors learned how they might use *Texas Through Time* in courses they teach.

In community outreach, the Bureau hosted the Austin Regional Sierra Club for presentations about environmental research. **Michael Young**, **Sue Hovorka**, **Bridget Scanlon**, **Brad Wolaver**, **Daniel Ortuño**, and **Linda Ruiz McCall** each spoke, and the group also toured the Austin Core Repository with **Nathan Ivicic** and **Brandon Williamson**. Presentations were also given to the Austin Gem and Mineral Society and the 2017 Boy Scout STEMboree.



Bureau associate director Michael Young shows core samples to members of the Austin Regional Sierra Club.

Conference for the Advancement of Science Teaching

Bureau project manager **Juli Hennings** and information geologist **Linda Ruiz McCall** presented



Juli Hennings



Linda Ruiz McCall

information on the Bureau's new radio program *EarthDate* to K-12 educators at the Conference for the Advancement of Science Teaching (CAST) in Houston in November. Hosted by the Science Teachers Association of Texas, CAST draws over 5,500 science educators from across the state to provide professional development and resources

to advance K-12 science education in Texas.

Research Scientist Associate **Beverly DeJarnett** of the Bureau and Jason Barrett of the Texas Department of Transportation (TxDot) also distributed hundreds of rock and mineral posters, rock kits, maps, and informational brochures in the CAST Exhibit Hall. American Geosciences Institute Earth Science Week Toolkits, rock kits, and hundreds of page-sized maps were also donated to the Texas Earth Science Teachers Association for distribution to their members statewide.

For additional information about the K-12 educational and outreach resources offered by the Bureau, please contact McCall at linda.mcCall@beg.utexas.edu.

Organizations Reached in 2017

K-16 Educators

Aldine ISD secondary science teachers

Conference for the Advancement of Science Teaching

Groundwater to the Gulf Institute

NASA Center for Space Research Blue Dot teacher workshop

Texas Association of Community Colleges annual meeting

Texas Environmental Advisory Council annual meeting

Texas Mining and Reclamation Association Industrial Minerals workshop

K-16 Students

Akins High School OnRamp Academy

Austin Earth Science Week Career Day

Austin Elementary School, Irving

Austin Families in Nature

Austin Geological Society Science Fair winners

Austin Youth Council Career Fair

GeoFORCE 12th-grade Summer Academy

San Angelo State undergraduate geology students

Schlumberger Externship program

Community Outreach

Austin Gem and Mineral Society

Austin Regional Sierra Club

Boy Scout STEMboree



Jason Barrett of TxDot and Beverly DeJarnett of the Bureau distribute maps, rock kits, and posters at the Bureau exhibit booth at CAST.

Honors

2017 Joseph C. Walter Excellence Award: Michael H. Young



Michael Young

Bureau of Economic Geology associate director (Environmental Division) **Michael H. Young** was honored by UT Austin's Jackson School of Geosciences (JSG) with the 2017

Joseph C. Walter Excellence Award in late December. The Walter Award—the highest honor that the JSG bestows on faculty members and research scientists each year—

recognizes demonstrated excellence in any or all areas of the school: research, teaching, service, professional activity, and administration.

JSG dean **Sharon Mosher** acknowledged Young's contributions to the school. "Michael has advanced the Bureau's environmental group to new heights and is recognized internationally for his research in soil science," she said. "His administrative and research work have tru-

ly enhanced the reputation of the Bureau and the Jackson School. His work ethic is inspiring. As associate director, he has helped lead large research programs, like the Texas Soil Observation Network; the use of airborne lidar for high-resolution terrestrial scanning and 3D geologic mapping programs; and the TexNet Seismic Monitoring Program....He deserves special recognition from the school for his successes in making geoscience serve humanity."

Alumnus of the Year Award: Jay Raney



Jay Raney (left) with Bureau director Scott W. Tinker.

Jay Raney received the Bureau's Alumnus of the Year Award during the Jackson School of Geosciences Friends and Alumni Reception at the Geological Society of America annual meeting in Seattle in October. Given annually since 2003, this award honors former Bureau employees for significant career accomplishments after leaving the Bureau. Raney began working at the Bureau in 1985 as a research

scientist. He served as associate director of the Environmental Division from 1994 through 2004 and retired from the Bureau in 2006.

Raney received a handcrafted brass Brunton compass inspired by an antique pocket model, once commonly used by geologists and engineers during the days when instruments of exploration were works of art as well as survival tools.

2018 William B. Joyner Lecture Award: Ellen Rathje



Ellen Rathje

UT Austin professor and Bureau senior research scientist **Ellen M. Rathje** is the 2018 recipient of the William B. Joyner Lecture Award, announced in October

by the Earthquake Engineering Research Institute (EERI) and the Seismological Society of America (SSA) to honor outstanding earth science contributions.

Dr. Rathje is the Warren S. Bellows Centennial Professor in UT Austin's

Department of Civil, Architectural, and Environmental Engineering. At the Bureau, she serves as co-principal investigator for the **Center for Integrated Seismicity Research** and the **TexNet Seismic Monitoring Program**.

SEPM James Lee Wilson Award: Jake Covault

Bureau research scientist **Jacob A. Covault** received the 2017 James Lee Wilson Award in recognition of “Excellence in Sedimentary Geology by a Young Scientist” from the Society for Sedimentary Geology (SEPM) at their annual meeting in Houston in April. The award is presented to young geoscientists “who have achieved a significant record of research accomplishments in sedimentary geology, including all aspects of modern and ancient sedimentology, stratigraphy, and paleontology, fundamental and applied.”

Dr. Covault joined the Bureau in 2015; he is the principal investigator of the **Quantitative Clastics Laboratory**

(QCL), an industry research collaboration focused on the sedimentology and stratigraphy of clastic depositional systems, with applications in reservoir modeling, uncertainty in subsurface stratigraphic correlation, and source-to-sink predictions for frontier exploration.

Established in 1996, the award was named in honor of James Lee Wilson, an internationally recognized expert on the geology of carbonate sedimentary rocks.



SEPM president (2016–17) Vitor Abreu (left) with Wilson Medal winner Covault.

For information on SEPM awards:

<https://www.sepm.org/pages.aspx?pageid=74>

Bureau Publication Awards

In April, the Bureau held its annual First Author Publication Awards dinner to celebrate the peer-reviewed publishing achievements of its researchers in 2016. Bureau authors produced 150 publications in 2016 (up from around 140 the year before). Of these, 55 were written or co-written by 39 Bureau first authors; another 11 papers were written by graduate-student first authors directly supervised by Bureau researchers.

Bridget Scanlon, Alex Sun, Farzam Javadpour, and Bob Loucks were the most prolific authors of peer-reviewed publications in 2016, with Scanlon publishing 13 first- or co-authored papers. **Kitty Milliken, Esti Ukar,** and postdoc **Xinming Wu** had the most first-authored papers, with 4 apiece. **Sergey Fomel** was co-author on 5 papers first-authored by his Ph.D. students.

The evening also featured the presentation of the Tinker Family BEG Publication Award to Robert Baumgardner, **Scott Hamlin,** and **Harry Rowe** “in recognition of the publication’s scientific and economic impact on our understanding of the Wolfcamp Formation and Leonardian succession in the Midland Basin” for their “Lithofacies of the Wolfcamp and Lower Leonard Intervals, Southern Midland Basin, Texas” (2016, **Bureau Report of Investigations No. 281**). Runners-up were Milliken and co-authors “in recognition of career contributions to sedimentary petrology in top-tier journals” for “Quartz types, authigenic and detrital, in the Upper Cretaceous Eagle Ford Formation,



Director Tinker (right) presents the Tinker Family BEG Publication Award to Robert Baumgardner (left) and Scott Hamlin.

South Texas” (2016, *Sedimentary Geology*, v. 339) and “Organic matter-hosted pore system, Marcellus Formation (Devonian), Pennsylvania” (2013, *AAPG Bulletin*, v. 97).

Said the dinner’s host, Director **Scott W. Tinker**, “We’ve come a long way in peer-reviewed publishing, in quantity, quality, and breadth.”

Dutton, Paine Top Bureau Staff Service Awards



In May, the Bureau recognized recipients of this year's UT Austin Staff Service Awards. Twenty-two Bureau staff members were acknowledged for their contributions, achievements, and length of service.



Jeffrey Paine

Notable among these were Senior Research Scientist **Shirley Dutton**, who this year completed 40 years of service at the Bureau, and Senior Research Scientist **Jeffrey Paine**, with 35 years of service. Recipients were previously recognized by UT at the President's Staff Awards ceremony in April.

UT Austin president Gregory L. Fenves presents Dutton with her Staff Service Award for 40 years of service. (Photo by Brian Birzer.)

2016 Staff Excellence Award: Nathan Ivicic



Ivicic (right) accepts the Bureau's 2016 Staff Excellence Award from Director Scott W. Tinker at the staff appreciation cookout in July.

Warehouse Supervisor **Nathan Ivicic** was named the recipient of the 2016 Bureau of Economic Geology Staff Excellence Award for his remarkable performance overseeing the maintenance of the organization's vast core and rock material archives at the **Austin Core Research Center (CRC)** and the **Midland Core Research Center**. Ivicic's organizational ability,

can-do spirit, and service-first attitude were major factors in the unanimous decision by the Bureau's leadership group to nominate him for the award.

Ivicic, who started working at the Bureau as a student, is now in his 15th year here.

Student Spotlight

Caudle Simple Energy Concepts Prize: Matt Ramos



Matt Ramos

Ph.D. student **Matt Ramos** was the first-place award winner of the 5th Ben Caudle Simple Energy Concepts Contest sponsored

by UT Austin's Department of Petroleum and Geosystems Engineering (PGE). Matt's winning topic was "Electrical resistivity vi-

sualization for identifying subsurface fluids."

The contest, which honors former PGE professor emeritus Ben Caudle, seeks to develop ideas that convey complex geologic flow-related topics using simple concepts. Winners receive funding from the department to construct a demonstration of the concept and present it at various venues, such as UT Austin's "Introduce a Girl to Engineering Day" and "Explore UT."

Ramos' Ph.D. dissertation—supervised by **Stephen E. Laubach**, Bureau senior research scientist and **Fracture Research and Application Consortium (FRAC)** principle investigator, and Nicholas Espinoza of the PGE—pertains to laboratory characterization of shale anisotropy and natural fracturing through combined triaxial stress testing and ultrasonic wave propagation.

Continued on page 31

NASA Earth and Space Science Fellowship: Chuck Abolt

In April, Ph.D. student **Chuck Abolt** was awarded a NASA Earth and Space Science Fellowship for his work on arctic soils, “Feedbacks between topography and three-dimensional fluxes of heat, water, and carbon in ice wedge polygons.” Abolt is one of just 69 awardees chosen from 385 applicants in the Earth science field; his award was based on scientific merit, relevance to NASA’s objectives in Earth and space science, and academic excellence.

Working with Ph.D. advisor and Bureau associate director **Michael Young** as principal investigator, Abolt will explore two hypotheses regarding changing topography and the interrelationships between heat, water, and soil carbon levels of ice-wedge polygons to better understand

the geomorphology of the Alaskan tundra. The study will employ an advanced 3D computer model of thermal hydrology, with simulations calibrated against continuing subsurface temperature observations at six depths and resulting concepts to be extrapolated to a second site. The study also includes development of a software application to survey a study area of more than 480 sq km of tundra to estimate rates of groundwater release at a landscape scale.

The 2-year study, which began in September 2017, will employ data from the Fourier Transform Spectrometer flown on NASA’s CARVE mission



Advisor Michael Young (left) and award winner Chuck Abolt on the tundra in Alaska.

and the OCO-2 satellite to determine whether differences in carbon emissions from different ice-polygon types can be detected using airborne and spaceborne sensors.

Energy and Earth Resources Director’s Award: Abdulaziz Almansour

Master’s candidate **Abdulaziz Almansour** is the recipient of the 2017 Director’s Award from the Energy & Earth Resources (EER) Graduate Program in recognition of his insightful research and an outstanding presentation of his work at the Jackson School Master’s Saturday symposium held in April. The recognition is accompanied by a cash prize, which Almansour shares with fellow EER student Ben Griffiths. Almansour was also a finalist among Jackson School students for an award for the best-written abstract.

Almansour’s research, “VOI of fracture prediction methods,” applies geologic, engineering, and economic analysis to evaluate the technical

effectiveness and economic value of a fracture-characterization method that uses limited subsurface information to diagnose the presence or absence of open fractures. Software that Almansour developed as part of the study allows decision makers to calculate the value of information using play-specific geologic and cost parameters to evaluate any type of technology or test. One outcome of the research on the fracture-diagnostic method is a tangible demonstration of the high economic value of new, fundamental insights into natural fracture processes developed in the Structural Diagenesis Initiative program.

Almansour’s research supervisors are the Bureau’s **Stephen E. Laubach**,



Director’s Award winner Abdulaziz Almansour.

PI of the **Fracture Research and Application Consortium**, and Eric Bickle, professor of Operations Research and Industrial Engineering at UT Austin.

Publications

Bureau Data Now Available in Geofacets™

Elsevier, the information analytics company specializing in science and health, announced that content from the Bureau of Economic Geology is now available in Geofacets, Elsevier's online database for research of surface and subsurface geology. The Bureau's content in Geofacets will help both conventional and unconventional oil and gas companies discover economically viable hydrocarbons in Texas, particularly in the Permian and Gulf Coast Basins

and other tight oil and shale gas plays in the state.

The Bureau's data has been enriched, enhanced, and digitized in Geofacets, making its maps, figures, and table data easily accessible. More than 6,500 maps (4,000 geo-referenced), 1,700 figures, and 200 tables were added to Geofacets from Bureau content. The data—sourced from geological circulars, Reports of Investigations, and atlases of major oil and gas reservoirs—adds

to Geofacets' comprehensive portfolio, which consists of more than 1.5 million maps, figures, and tables from nearly 100 publications. The additional content focuses on natural resource exploration, including bore-hole/core location, play (fairway), well location (oil/gas), structural geology and tectonics, sedimentology, and stratigraphy data.

Visit: <https://www.elsevier.com/solutions/geofacets>.

Guidebook

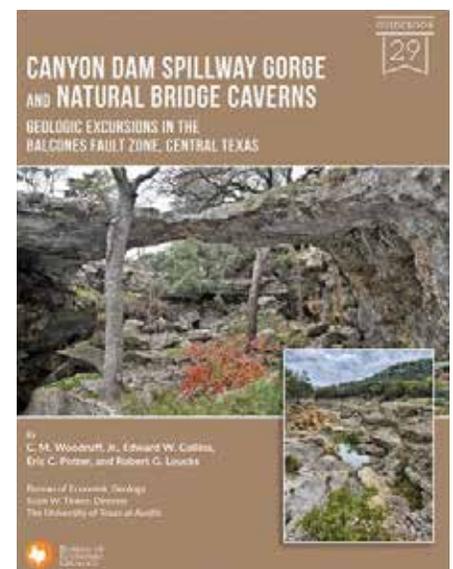
Canyon Dam Spillway Gorge and Natural Bridge Caverns: Geologic Excursions in the Balcones Fault Zone, Central Texas

Woodruff, C. M., Jr, Collins, E. W., Potter, E. C., and Loucks, R. G., 2017, The University of Texas at Austin, Bureau of Economic Geology, Guidebook No. 29, 56 p., 29 figs., 1 appendix, 2 appendix figures, 1 color plate.

The latest Bureau guidebook—by **Chock Woodruff**, **Eddie Collins**, **Eric Potter**, and **Robert Loucks**—focuses on two spectacular geologic sites, Canyon Dam Spillway Gorge and Natural Bridge Caverns, which both occupy the Balcones Fault Zone in Comal County between Austin and San Antonio. These sites provide contrasting views of the limestone terrains west of the Balcones Escarpment, which cuts through Central Texas and marks the eastern edge of the Hill Country. The sites occupy roughly the same sequences of Cretaceous bedrock strata, but the different hydrologic processes that acted on

the strata produced dramatically different landforms over disparate intervals of time, imparting important geologic lessons about how landscapes evolve.

This guidebook begins with a road log for the entire excursion that starts and ends in Austin. Specific locations along the route are keyed to mileages presented in the road log to aid navigation and provide on-ground reference points for running commentaries about points of geologic, geographic, cultural, or historical interest. Separate articles present guided tours for each of the two stops. An appendix summarizes



geochemical processes of water on limestone terrains.

GB0029 can be purchased online at The Bureau Store or in the Publication Sales bookstore at the Bureau.

Reports of Investigations

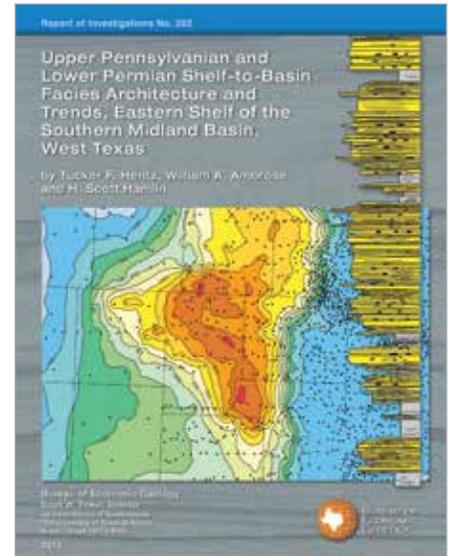
Upper Pennsylvanian and Lower Permian Shelf-to-Basin Facies Architecture and Trends, Eastern Shelf of the Southern Midland Basin, West Texas

Hentz, T. F., Ambrose, W. A., and Hamlin, H. S., 2017, The University of Texas at Austin, Bureau of Economic Geology, Report of Investigations No. 282, 68 p., 40 figs., 2 tables, 2 appendices, 1 plate, and 1 CD in back pocket.

RI0282 by **Tucker Hentz**, **William Ambrose**, and **Scott Hamlin** will be of special interest to those seeking detailed knowledge of the eastern Permian Basin. This study is the first comprehensive examination of the depositional framework of the entire southern portion of the Eastern Shelf of the Midland Basin, an area comprising approximately 15,500 sq mi in this major West Texas petroleum province.

The report provides detailed descriptions and interpretations of

whole cores representing key depositional intervals; seven regional, shelf-to-basin, fold-out transects of all formation tops within the study area; and a downloadable spreadsheet of the more than 25 Canyon-Cisco formation tops of the 266 transect wells and 2,247 total study wells. This study provides a starting point for those interested either in the detailed stratigraphic context of local oil or gas fields or the facies framework for more regional study.



Geological CO₂ Sequestration Atlas of Miocene Strata, Offshore Texas State Waters

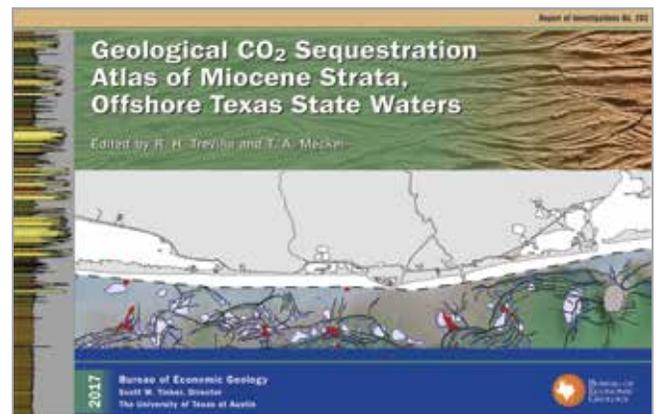
Treviño, R. H., and Meckel, T. A., eds., 2017, The University of Texas at Austin, Bureau of Economic Geology, Report of Investigations No. 283, 74 p., 7 chapters, 1 appendix.

RI0283, edited by **Ramon Treviño** and **Tip Meckel**, summarizes research undertaken as part of a multiyear study (2009–2014) of Texas State Waters and the adjacent Federal Offshore Continental Shelf. The goal of the study was to assess and analyze existing data from historical hydrocarbon-industry activities in a regional transect of the Texas coast in order to verify the ability of Miocene-age rocks of the region to safely and permanently store large amounts of anthropogenic (industrial) CO₂.

Prior hydrocarbon exploration history has set the stage for successful and low-risk carbon capture and storage (CCS) deployment at offshore locations in general, and the near-offshore waters of Texas in particular, for reasons including suitable

geology, abundant and high-quality geologic data sets, proximity to CO₂ sources, and reduced risk to shallow sources of drinking water.

The atlas provides a resource for exploring the geological CO₂ sequestration potential of the near-offshore waters of Texas via large-scale regional and qualitative, as well as detailed quantitative, information that can help operators quickly assess CO₂ sequestration potential at specific sites. This is the first comprehensive attempt to accomplish



this goal in the near offshore Gulf Coast and United States.

RI0282 and **RI0283**, now available in both softcover and downloadable digital versions, can be purchased online at The Bureau Store or in the Publication Sales bookstore at the Bureau.

Maps

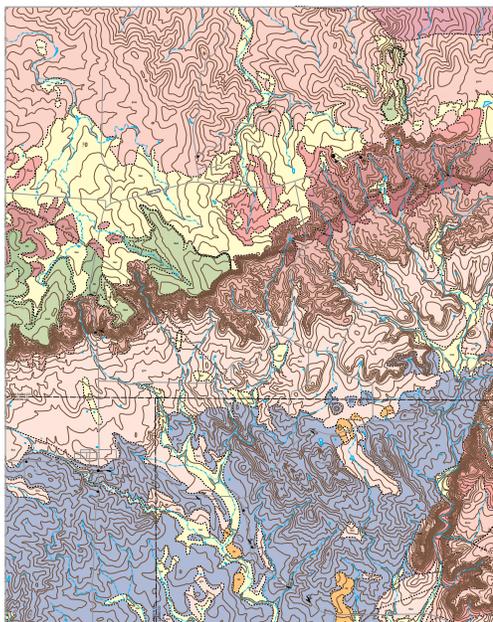


Geologic Map of the Mansfield Dam Quadrangle, Texas

Woodruff, C. M., Jr., 2017, The University of Texas at Austin, Bureau of Economic Geology, Open-File Map, **OFM0229**, scale 1:24,000.

The dominant surface features on this map include impounded meanders of the Colorado River and its tributaries that compose the lower reaches of Lake Travis. The river has cut into Lower Cretaceous strata that dip gently to the southeast and include localized exposures of Cow Creek Limestone and Hensel Sand along lakeshore at the map's western edge. The highest elevations on the map have formed on the Edwards Limestone that composes outliers of the once-continuous Edwards Plateau. The most areally extensive geologic formation across this area is the Glen Rose Limestone, consisting of upper and lower members as well as an informal map unit at the formation's top that is composed chiefly of weathered silty dolomitic strata. This map includes classic landscapes of the Central Texas Hill Country, with multiple high-gradient ephemeral water courses draining disjunct plateau

uplands and sculpting stepped terrain from diverse underlying strata. Relief of more than 460 ft occurs above lake level along the abrupt meander bed east of Mansfield Dam; the lake depth in this area adds another 200-plus ft to the pre-impoundment topographic relief. Local Quaternary alluvial deposits occur downstream from the dam, but elsewhere most of these deposits lie inundated beneath the lake.



Geologic Map of the Pontotoc Quadrangle, Texas

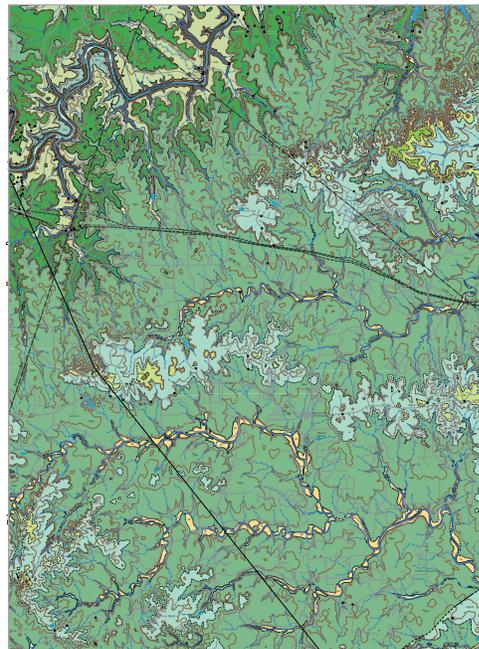
Elliott, B. A., 2017, The University of Texas at Austin, Bureau of Economic Geology, Open-File Map, **OFM0230**, scale 1:24,000.

This map, one of several 1:24,000-scale maps of the region north of the Llano Uplift, focuses on sand resources in the Cambrian and Ordovician stratigraphy of Central Texas. Maps for this region provide a basic geologic framework to aid in managing water and earth resources; planning land use; identifying aquifer recharge areas; and identifying earth resources such as dimension stone, aggregate, construction sand and specialty sand, and gravel. This study area lies north of Llano Uplift Precambrian Valley Spring gneiss, within the Cambrian-age Hickory Formation eolian to near-shore setting; is transitional to marine transgressional through the Wilberns and Tanyard Formations; and is overlain by Cretaceous limestone and sandstone. The Hickory Formation is an important sand resource in Central Texas, and the Hickory aquifer recharge zone is important for water resource management in the region.

Geologic Map of the Shingle Hills–Dripping Springs–Driftwood–Rough Hollow–Henly–Hammetts Crossing Area, Central Texas

Collins, E. W., 2017, The University of Texas at Austin, Bureau of Economic Geology, Open-File Map, **OFM0231**, scale 1:50,000.

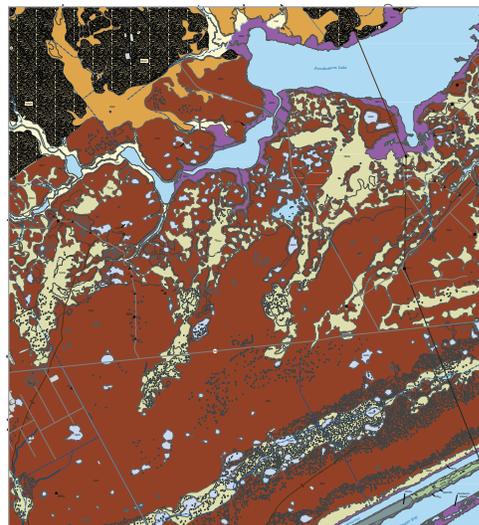
This map area lies mostly within the dissected eastern margin of the Edwards Plateau west of Austin, which is experiencing relatively rapid suburban and local urban development. Geology of the map area consists of as much as 900 ft of Lower Cretaceous shelf- and shore-zone deposits. Map units include Sycamore Sand, Hammett Shale, Cow Creek Limestone, Hensel Sand, upper and lower Glen Rose Limestone, Walnut Formation, and Edwards Limestone.



Geologic Map of the Seadrift NE Quadrangle, Texas Gulf of Mexico Coast

Paine, J. G., and Collins, E. W., 2017, The University of Texas at Austin, Bureau of Economic Geology, Open-File Map, **OFM0232**, 2 sheets (sheet 1: scale 1:24,000; sheet 2: digital-elevation model, geophysical logs, time-domain electromagnetic induction soundings, and frequency-domain electromagnetic induction measurements).

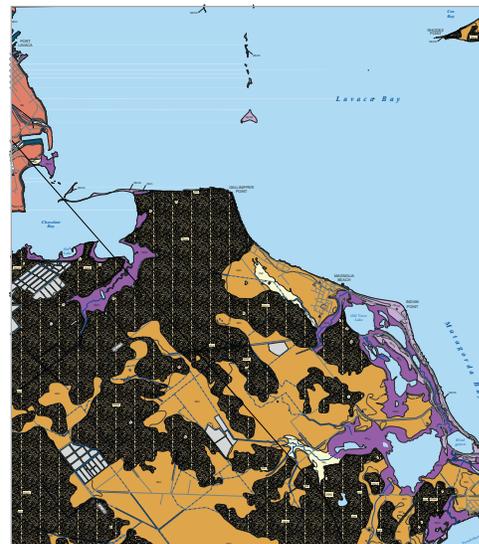
This map illustrates the geology at the southern margin of Powderhorn Lake and the western part of Powderhorn Ranch, a planned state park and wildlife management area near Port O'Connor. The area's geology consists of sediments deposited within Pleistocene barrier and fluvial-deltaic systems and a Holocene bay-estuary system. Map units include Pleistocene barrier and deltaic deposits and Holocene bay margin and valley margin deposits.



Geologic Map of the Port Lavaca East Quadrangle, Texas Gulf of Mexico Coast

Paine, J. G., and Collins, E. W., 2017, The University of Texas at Austin, Bureau of Economic Geology, Open-File Map, **OFM0233**, 2 sheets (sheet 1: scale 1:24,000; sheet 2: digital-elevation model, time-domain electromagnetic induction sounding, and frequency-domain electromagnetic induction measurements).

This map illustrates the geology at the northern margin of Powderhorn Lake and the western margin of Matagorda and Lavaca Bays. The area's geology consists of sediments deposited within a Pleistocene fluvial-deltaic system and a Holocene bay-estuary system. Map units include Pleistocene muddy and sandy facies of a fluvial-deltaic setting and Holocene bay-margin deposits.



Peer-Reviewed Publications by Bureau Researchers

- Abolt, C. J., Young, M. H., and Caldwell, T., 2017, Numerical modelling of ice-wedge polygon geomorphic transition: Permafrost and Periglacial Processes, v. 28, no. 1, p. 347–355, <http://doi.org/10.1002/ppp.1909>.
- Afsharpoor, A., Javadpour, F., Wu, J., Ko, L. T., and Liang, Q., 2017, Network modeling of liquid flow in Yanchang shale: Interpretation, v. 5, no. 2, p. SF99–SF107, <http://doi.org/10.1190/INT-2016-0100.1>.
- Ambrose, W. A., Dutton, S. P., and Loucks, R. G., 2017, Depositional systems, facies variability, and their relationship to reservoir quality in the Jurassic Cotton Valley Group, Texas, Louisiana, and Mississippi onshore Texas Gulf Coast: GCAGS Journal, v. 6, p. 21–46.
- Anderson, J. S., Romanak, K. D., Yang, C., Lu, J., Hovorka, S. D., and Young, M. H., 2017, Gas source attribution techniques for assessing leakage at geologic CO₂ storage sites: evaluating a CO₂ and CH₄ soil gas anomaly at the Cranfield CO₂-EOR site: Chemical Geology, v. 454, p. 93–104, <http://doi.org/10.1016/j.chemgeo.2017.02.024>.
- Arciniega-Esparza, S., Breña-Naranjo, J. A., Hernández-Espriú, A., Pedrozo-Acuña, A., Scanlon, B. R., Nicot, J.-P., Young, M. H., Wolaver, B. D., and Alcocer-Yamanaka, V. H., 2017, Baseflow recession analysis in a large shale play: climate variability and anthropogenic alterations mask effects of hydraulic fracturing: Journal of Hydrology, v. 533, p. 160–171, <http://doi.org/10.1016/j.jhydrol.2017.07.059>.
- Bai, T., Tsvankin, I., and Wu, X., 2017, Waveform inversion for attenuation estimation in anisotropic media: Geophysics, v. 82, no. 4, p. WA83–WA93, <http://doi.org/10.1190/GEO2016-0596.1>.
- Bassant, P., Janson, X., van Buchem, F., Gurbuz, K., and Eris, K., 2017, Mut Basin, Turkey: Miocene carbonate depositional styles and mixed systems in an icehouse setting: AAPG Bulletin, v. 101, no. 4, p. 533–541, <http://doi.org/10.1306/011817DIG17032>.
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Transitions

In Memoriam



Dr. Peter T. Flawn

Dr. **Peter T. Flawn**, former UT Austin president (1979–1985; interim 1997–1998) and director of the Bureau of Economic Geology (1960–1970), passed away May 7; he was 91.

Upon becoming president of UT Austin in 1979, Dr. Flawn declared a “war on mediocrity,” pushing the University to pursue greater academic rigor and excellence. He helped raise the university’s number of faculty endowments from 112 to 851 with the Centennial campaign, and during his 6-year tenure, sponsored research awards grew to \$100 million and five new research buildings were built. The Academic Center was renamed the *Peter T. Flawn Academic Center*

in his honor in 1985, when he retired and became president emeritus.

Said current UT Austin president **Gregory L. Fenves**, “Peter was a visionary leader at UT, a beloved friend and a wise counselor to me and many university presidents. Whenever the university sought his help—from his earliest days doing geology research in West Texas through his time as president emeritus—Peter always answered the call. His contributions to our great university were immense and we will miss him deeply.”

Born in 1926, Dr. Flawn studied at Oberlin College and earned his doctorate in geology at Yale University. In 1949, after a stint at the U.S. Geological Survey, he began an illustrious career in geologic research at the Bureau, serving as director from 1960 to 1970, and as a professor in UT Austin’s Department of Geological Sciences. Dr. Flawn maintained his ties to the Bureau throughout his life. Said Bureau director **Scott W. Tinker**, “When we formed the Bureau’s Visiting Committee in 2000, Peter served as the first chair. I, and the Bureau, have benefited greatly

from his wise, and typically sparing, counsel for the past 17 years... Dr. Flawn was without question one of the finest the Bureau has ever produced—or ever will.”

In 2005, Dr. Flawn also helped establish the Jackson School of Geosciences. “Peter Flawn was inspiring as both a geologist and an academic leader,” said **Sharon Mosher**, dean of the Jackson School. “His field maps and publications on West Texas geology were an essential source for generations of students. And as president, his push for excellence at UT made a deep impression on me and many professors in the 1980’s, leading to profound and positive changes in the university.”

Dr. Flawn’s numerous scientific honors include election to the National Academy of Engineering in 1974, and serving as president of the Geological Society of America in 1978 and of the American Geosciences Institute (AGI) in 1988. In 1993, the AGI awarded him their most prestigious honor, the Ian Campbell Medal.



Donna Gail Hitzfeld “Cole” May, Bureau Administrative Associate from 1995 to 1999, passed away in 2017. Those who worked with her remember her cheerful personality and adept problem-solving skills.

Donna Gail Hitzfeld “Cole” May

Retirements

Robert Baumgardner retired in October after a long and varied career that included two stints



Robert Baumgardner

at the Bureau. After receiving both a B.A. with Special Honors in Zoology and an M.A. in Geology from UT Austin, Robert began his Bureau career in 1976 as a research assistant, then served as research scientist associate from 1979 to 1992, focusing on the West Texas Waste Isolation Project and the Low Level Radioactive Waste Project.

In 1992, Robert left the Bureau to pursue a career as a freelance photographer, shooting assignments for national and international publications including *Fortune*, *The New York Times*, *Texas Highways*, and *Texas Monthly*.

This 18-year detour ended in 2010 when Robert returned to the Bureau, first working on the State

Map Project before moving on to the **Mudrock Systems Research Laboratory** consortium, where his studies focused on Wolfcampian-age rocks of the Permian Basin. In 2014 he and co-author Scott Hamlin won the Charles J. Mankin Memorial Award presented by the Association of American State Geologists for Report of Investigations 277, "Wolfberry (Wolfcampian-Leonardian) Deep-Water Depositional Systems in the Midland Basin: Stratigraphy, Lithofacies, Reservoirs, and Source Rocks." In 2017 he, Hamlin, and Harry Rowe were awarded the Tinker Family BEG Publication Award for Report of Investigations 281, "Lithofacies of the Wolfcamp and Lower Leonard Intervals, Southern Midland Basin, Texas."

Robert's plans for retirement include "starting off slow and tapering off from there," with plenty of time for volunteer work; travel near and far with navigator/wife, Joan; and sorting through a lifetime of photo-

graphs. He leaves us with these parting words:

Setting My Chickens Free

(with apologies to William Butler Yeats, Taj Mahal, and the Fabulous Furry Freak Brothers)

I will retire and go now and set my chickens free.

Clean the chicken coop out and turn the WiFi on.

Rent that sucker out for South By on Airbnb

to out-of-towners and the hipster throng.

Gonna move on up the country, paint my mailbox blue,

and mow my lawn for lawns always need mowing.

Gonna bide awhile with Joan there in our bungalow for two.

And, now, it's almost time. I'll soon be going.

I will retire and go now for every night and day

a small voice says, "Let someone else describe that Wolfcamp core."

And so it's onward through the fog, as Oat Willie would say.

I take you in my mem'ry as I truck on out the door.



Rebecca Smyth

Bureau project manager **Rebecca C. "Becky" Smyth** retired at the end of August. Her Bureau adventures began in 1983 with study of Trans-Pecos igneous rocks. After leaving in 1985 to travel the globe, earn an MA in geology from UT Austin, and work as a hydrogeologist for private companies in Austin, Becky returned to the Bureau in 1997 to conduct hydrogeologic investigations of sites impacted by oil and gas activities. By 1999 she was helping to establish the airborne lidar program, mapping extensive areas along the Texas coast and other national and international locations. In 2006, Becky joined the CO₂ sequestration group, becoming a project manager in 2007. Her CO₂ group duties included study of onshore and offshore areas suitable for geologic storage of CO₂ and groundwater quality over CO₂ enhanced oil recovery fields. After a few months of retirement, Becky returned part-time to the Bureau in December to assist with new hydrogeology projects.

Visiting Committee



From left to right: John Gibson (Disruptive Technology), Mike Ming (Baker Hughes), George P. Bush (Texas Land Commissioner), Jim Farnsworth (Cobalt International Energy), Bud Scherr (Valence Operating Co.), Scott Anderson (U.S. Climate and Energy Program), Phillip Ashley (representing Glenn Hegar, Texas Comptroller), Claudia Hackbarth (Shell), Mark Houser (University Lands), Chuck Williamson (Weyerhaeuser Co. & Paccar), Dick Stoneburner (Pine Brook Partners), Christi Craddick (Railroad Commission of Texas), Jon Niermann (Texas Commission on Environmental Quality), Carol Lloyd (Exxon Mobil), Scott W. Tinker (Bureau Director), and Dan Domeracki (Schlumberger).

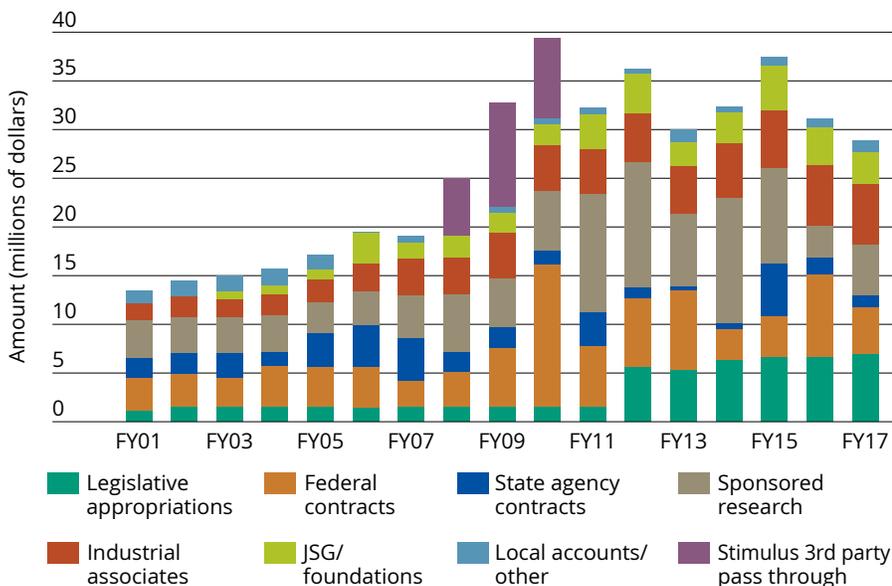
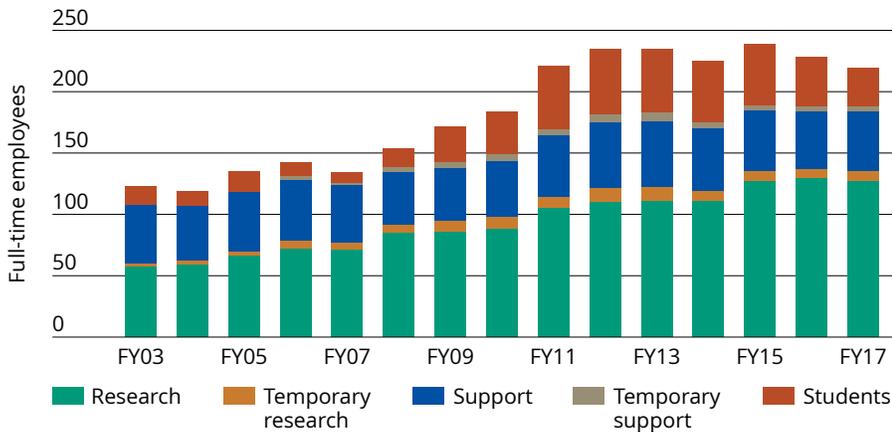
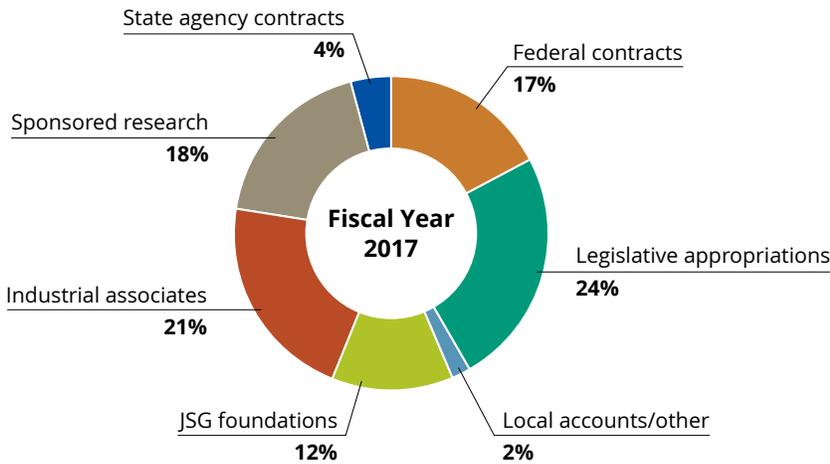
Leaders from Texas state government, industry decision makers, and major supporters gathered in August for the annual meeting of the Bureau's Visiting Committee, which provides vital counsel to the directorate and staff of the Bureau regarding research programs and opportunities, strategic direction, and other significant issues that help shape the future direction of Bureau research.

Discussion topics this year included the Bureau's impact on future industry challenges, how the Bureau can ramp up its utilization of "big data" and coming computer advances, and issues surrounding the use and re-use of water in hydrocarbon production. Bureau researchers and directors reported on several major initiatives, including the earthquake monitoring and mitigation program of the **TexNet/Center for**

Integrated Seismicity Research; ongoing research into water resources; the launch of the new 3D Resource Reserve and Production research consortium; and land assessment using lidar and other technological capabilities of the Bureau's Environmental Division.

Visit: <http://www.beg.utexas.edu/people/visiting-committee>

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