

Annual Report 2013



BUREAU OF
ECONOMIC
GEOLOGY

Scott W. Tinker, Director

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Front cover: Overhead stitched photograph of the waterfall and upper pond area from The Gorge at Canyon Lake, Texas. Photographs were acquired using an unmanned aerial vehicle (UAV) carrying a mounted digital camera. Photographs provided by Chris Zahm and Robert Younes (Camerawings, Inc.) as part of ongoing research within the Reservoir Characterization Research Laboratory (RCRL) group on the creation of digital outcrop models from UAV's.

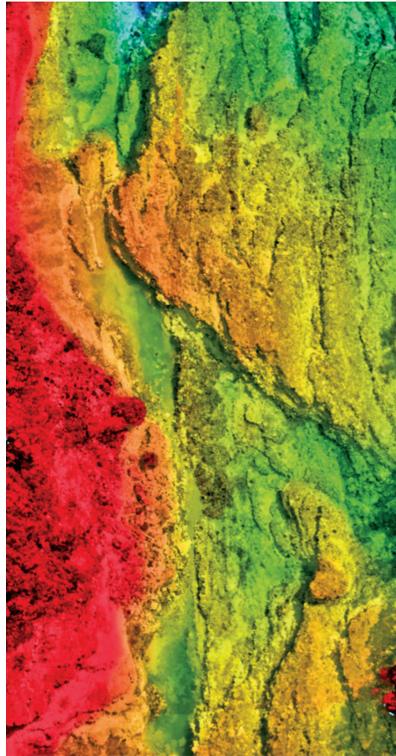


Image above: Somewhat expanded view from the cover, within a 3D digital elevation model created using more than 100 UAV-acquired photographs of the same area. Photographs were stitched together to create the model based on the principles of photogrammetry. The model was constructed by Josh Lambert, RCRL lidar and photogrammetry expert.

Service to Society



As I was beginning to write this draft, the phone rang. It was Collin Eaton, a reporter with the *Houston Chronicle*,

wanting to chat about shale oil. Appropriate, given the subject of this annual report.

In 2011, the Visiting Committee of the Bureau presented us with a very clear challenge. "You do great science," they said, "but no one hears about it." They were not talking about our scientific colleagues, with whom we communicate via peer-reviewed articles, at professional meetings, and the like. They were talking about the public: those who would benefit most from understanding how our science impacts their lives. In other words, what our advisors were suggesting was that we at the Bureau leave the protection afforded by peer-reviewed walls and fully engage in communication with society.

We took this challenge to heart.

We began to make our science understandable to lay audiences. We created a new position, manager of External Affairs, and now accept requests for interviews with newspapers, radio shows, television, and many forms of social media. We track the places where the Bureau appears in public media, and they are extensive.

In other words, what our advisors were suggesting was that we at the Bureau leave the protection afforded by peer-reviewed walls and fully engage in communication with society.

We began to engage more fully in projects that carry the likelihood—some might say the risk—of public scrutiny, such as research involving endangered species, induced earthquakes, reserve and production forecasting for rocks that require water and energy as part of the hydraulic fracturing process, sinkholes and other geologic hazards, carbon sequestration, global energy education, and other societal concerns.

We created a short video describing the Bureau in terms understandable to the public, and we partnered with *EarthSky* to write articles and conduct interviews about some of our major science programs. We hosted a 10-year anniversary CoreFest in the Houston Research Center, broadened the reach of Industry Day, and hosted our 14th Annual Earth Science Week Career Fair for middle-school kids.

In essence, we are answering the call to serve the public, and although what actually gets reported can be a bit frustrating at times, overall we are finding it extremely rewarding.

And the spirit of service certainly gave me motivation to explain porosity in shales to Collin, my new reporter friend from the *Chronicle*!



Service Section Includes:

- ▶ Science for Energy & Policy
- ▶ Mapping & Remote Sensing
- ▶ The Water-Energy Nexus
- ▶ Environmental Research
- ▶ Resources for the Public
- ▶ Assisting the General Public
- ▶ Developing Future Scientists

Science for Energy & Policy

Project STARR (State of Texas Advanced Resource Recovery)

STARR, in conjunction with the Mudrock Systems Research Laboratory (MSRL), co-funded the research summarized in BEG Report of Investigations No. 277, *Wolfberry (Wolfcampian-Leonardian) Deep-Water Depositional Systems in the Midland Basin: Stratigraphy, Lithofacies, Reservoirs, and Source Rocks* by Scott Hamlin and Robert Baumgardner. The new report documents Lower Permian stratigraphy and lithology in the Midland Basin, focusing on Wolfberry reservoirs and source rocks. Producing more than 55 million barrels in 2011, the Wolfberry is one of the

larger unconventional oil plays in the United States. Closely related plays in the Permian Basin have the potential to dominate U.S. shale oil production in coming years. This report establishes the stratigraphic framework for all the current oil resource plays in the Midland Basin.

Other STARR highlights in 2013 include a well-attended core workshop on the Bone Spring and Wolfcamp Formations, led by Seay Nance and Robert Baumgardner at the annual West Texas Geological Society meeting

in September. Tucker Hentz presented results from a regional study of the Eaglebine Trend in southeast Texas at the 2013 AAPG Annual Convention in May, and Iulia Olariu published results from a ground-breaking regional study of the Frio Formation in South Texas in the December 2013 issue of *Marine and Petroleum Geology*.



For more information:
<http://www.beg.utexas.edu/starr/>

U.S. Shale Gas

A new study, believed to be the most thorough assessment yet of the natural gas production potential of the Barnett Shale, foresees slowly declining production through the year 2030 and beyond and total recovery at greater than three times cumulative production to date. This forecast has broad implications for the future of U.S. energy production and policy.

The study, funded by the Alfred P. Sloan Foundation, integrates engineering, geology, and economics in a numerical model that allows for scenario testing

based on many input parameters. The study team completed the Barnett and Fayetteville Shale portions of the study in 2013, with the Haynesville and Marcellus Shale gas play portions of the study on target for completion in 2014.

In the base case for the Barnett Shale, the study forecasts a cumulative 44 trillion cubic feet (Tcf) of economically recoverable reserves, with annual production declining in a predictable curve from the current peak of 2 Tcf per year to about 900 billion cubic feet (Bcf) per year by 2030.

This forecast falls in between some of the more optimistic and pessimistic predictions of production from the Barnett and suggests that the formation will continue to be a major contributor to U.S. natural gas production through 2030.

The Bureau of Economic Geology's Sloan study examines actual production data from more than 16,000 individual wells drilled in the Barnett play through mid-2011. Other assessments of the Barnett have relied on aggregate views of average production, offering a "top down" view of production. The BEG study, in contrast, takes a "bottom up" approach, starting with the production history of every well and then determining what

(Continued on page 3)

areas remain to be drilled. The BEG team identified and assessed the potential in 10 production-quality tiers and then used those tiers to forecast future production more accurately. The economic feasibility of production varies tremendously across the basin, depending upon production-quality tier. The result is a more accurate and comprehensive view of the basin.

The study's model allows for variations in natural gas prices, volume drained by each well, economic limit of a well, advances in technology, gas-plant processing incentives, and many other factors to determine how much natural gas operators will be able to extract economically.

"We have created a very dynamic and granular model that accounts for the key geologic, engineering, and economic parameters, and this adds significant rigor to the forecasts," said Svetlana Ikonnikova, energy economist at the BEG and co-principal investigator of the project.

Whereas thickness and porosity affect the reserves greatly, price is a dominant factor affecting production. Although the BEG model shows the correlation between price and production, it also suggests that price sensitivity is not overly dramatic, at least in the early phase of a formation's development. This low degree of price sensitivity persists because there are still many locations to drill in the better rock, making drilling cost-effective even at lower prices, explains Scott Tinker, BEG Director and co-principal investigator.

"Drilling in the better rock won't last forever," Tinker said, "but there are still a few more years of development remaining in the better rock-quality areas."

The data in the model stop at the end of 2010, after approximately 15,000 wells had been drilled in the field. In the base case, the assessment forecasts another

13,000 wells to be drilled through 2030. In 2011–2013, the actual number of wells drilled and annual production were very much in line with the forecast, leaving just over 10,000 wells remaining to be drilled through 2030 in the base case. Wells range widely in their ultimate recovery of natural gas, a factor the study takes into account.

A new method of estimating production for each well, based on the physics of the system, was integral to the project and should offer a more accurate method of forecasting production declines in shale gas wells. This method, along with several other components in the work flow, has been published in several manuscripts in peer-reviewed journals. Before submitting the papers to journals, the BEG team invited an independent review panel with members from government, industry, and academia to critique their research. At an open day for academics and industry scientists, 100 attendees were invited to offer additional feedback. Scientists and engineers from two of the larger producers in the Barnett—

Devon Energy and ExxonMobil—offered critical feedback on the methodology during two in-house corporate review days.

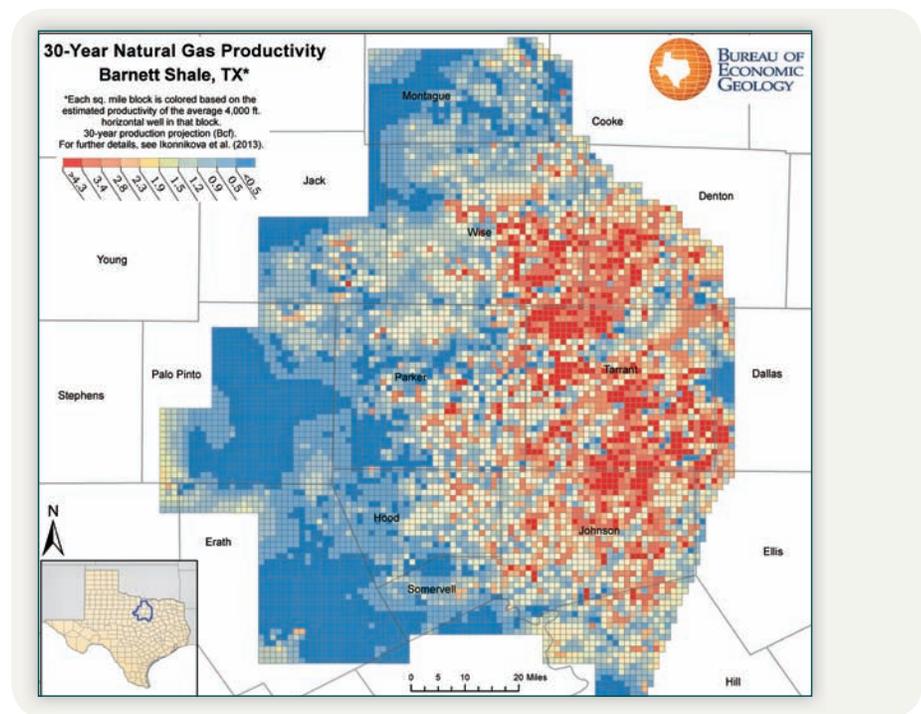
Overall, the rigorous assessment of the country's second most productive shale gas formation reaffirms the transformative, long-term impact of shale and other unconventional reservoirs of oil and gas on U.S. energy markets.

Tinker compared the expansion of hydrocarbon reserves from shale gas to the expansion of global oil reserves from deep-water exploration that has happened in the past several decades.

"Drilling into unconventional reserves is potentially analogous to offshore oil in terms of impact," Tinker said.

The team has now been funded by the Sloan Foundation to study shale oil and will examine the Eagle Ford in South Texas and the Bakken in North Dakota.

For more information: http://www.beg.utexas.edu/info/shale_rsrvs_prod.php



Expert Testimony and Government Committee Service

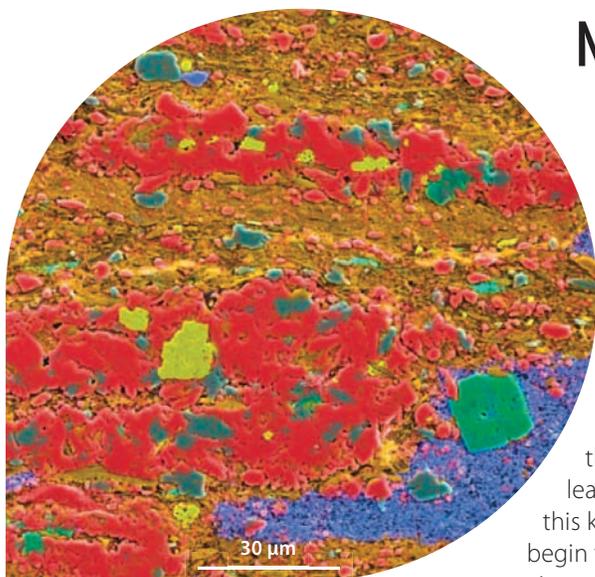
The Bureau of Economic Geology occupies a vital space at the intersection of academia, industry, and government, and serves as a bridge for the exchange of ideas and information among all three sectors. That service leads to many opportunities to present expert testimony to legislators and government committees at the local, state, and national levels. Bureau researchers also frequently serve the public good by lending their time and expertise to committees established by legislatures or government agencies to address issues of energy or the environment.

In 2013, Bureau experts gave testimony to committees of the U.S. House and Senate and the Texas Legislature, and provided briefings and workshops

to leaders and staff of Federal agencies (including the Environmental Protection Agency, the General Accounting Office, and the Nuclear Regulatory Commission) and State agencies (including the Texas Public Utilities Commission and the Electric Reliability Council of Texas).

Findings by Bureau researchers are widely accessed by agencies of the U.S. government; other national governments; and organizations, such as the International Energy Agency, that evaluate energy policy and the global supply of and demand for energy.

The Bureau is proud to support the critical mission of providing sound scientific information to shape energy legislation and policy.



New Scanning Electron Microscope Technologies for Understanding of Shales

Images such as the one on the left, an X-ray map collected by a field emission scanning electron microscope, reveal a wealth of information. We can see specific minerals and how they are distributed, as well as learn about the rock's history. With this kind of understanding, we can begin to build a more comprehensive view of mudrock diversity, allowing

operators to target the mudrocks most likely to host oil and gas, and thus more efficiently develop the play. Investment in technology for high-resolution imaging is yielding tremendous advances in our understanding of shale and other unconventional reservoirs.

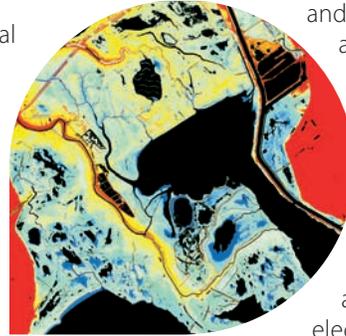
For more information:
<http://www.beg.utexas.edu/msrl/index.php>

Mapping & Remote Sensing

Near-Surface Observatory

The Bureau's Near-Surface Observatory is the umbrella for airborne, surface, and shallow-borehole geophysical and remote-sensing studies. Most of the group's activity in 2013 centered on our new airborne lidar and imaging system, called Chiroptera, which completed its first full year in-house. Its high-resolution topographic and bathymetric mapping capabilities were applied to a variety of coastal, minerals-mapping, and geohazard investigations in Texas and beyond. Program highlights include completion of a major survey on the Alaskan North Slope for wetlands, permafrost-feature mapping, and shallow-lake bathymetry. The results of this project were published in *The Leading Edge*. We also used the system in four new Texas coastal projects, including assessing shoreline change in major bay systems, determining the susceptibility of coastal rookeries to oil spills, establishing beach and nearshore sediment budgets for a rapidly eroding segment of Padre

Island, and assisting the General Land Office in delivering lidar survey results rapidly to emergency responders and the general public. Beyond the Texas coast, missions included a topographic and shallow-bathymetric survey of the Wax Lake delta in Louisiana for Jackson School researchers; a shoreline and nearshore survey near Monterey, California, for UT's Applied Research Laboratories; a tortoise-habitat survey in Nevada for county government; a pilot study to explore whether bathymetric lidar can be used to quantify the volumes of water pits supporting hydraulic fracturing activities in West Texas; a high-resolution topography and



imagery mission to support minerals-mapping activities in far West Texas; a survey to quantify decadal-scale subsidence surrounding the Wink sinkholes near Kermit, Texas; and a local survey to assess the effects of October 2013 flooding along Onion Creek. Other significant observatory endeavors included an airborne electromagnetic and magnetic survey near Cranfield, Mississippi, to support an ongoing carbon sequestration experiment, led by the BEG's Gulf Coast Carbon Center; and surface geophysical mapping of upper Quaternary fluvial, deltaic, and marine deposits on the central Texas coast and high Quaternary terrace deposits associated with the Colorado River in Central Texas.

For more information:
http://www.beg.utexas.edu/nso/index_wk.php

Mineral Resources Program

During the past year, Dr. Brent Elliott of the Bureau's mineral resources program developed an interactive online map of Texas mineral resources. This map is accessible to the public and shows where past and present mineral prospects have been identified around the state. Clicking on a locality brings up a window that provides a photo, a description of the resource, and other pertinent information (as well as publication references where more information

can be found). Plans are in the works to create site-specific geology links for each location, so that the public can learn more about Texas resources and teachers can use the map in earth-science classrooms. Bureau scientists also plan to use the Bureau's new airborne hyperspectral system to characterize rocks and minerals found on the ground surface. This type of system is critical for quickly covering large, remote areas and for identification of areas having the

highest potential for economic mineral-resources development. It would take years for a geologist on the ground to cover the territory that an airborne hyperspectral survey can cover in a few days.

For more information:
<http://www.beg.utexas.edu/minerals/index.php>
 and
<http://igor.beg.utexas.edu/txmineralresources/>



Geologic Mapping

Maps illustrating interpretations of the Earth's surface geology and related derivative maps, cross sections, stratigraphic columns, and geologic descriptions are some of the products that the Bureau has traditionally provided to the public. These geologic map products are typically used by professionals in geology, hydrology, engineering, urban planning, archeology, biology, and related fields, as well as by policymakers, teachers, students, and laypersons. Managing water and land resources, identifying earth resources (sand and aggregate), recognizing areas prone to foundation problems, and

evaluating changes in sensitive coastal environments are a few examples of the many uses of geologic maps. Bureau geologic mapping projects include the STATEMAP program, which is part of the National Cooperative Geologic Mapping Program administered by the U.S. Geological Survey, and a component of the Bureau's STARR program that deals with mapping and studying mineral and earth resources and geologic hazards.

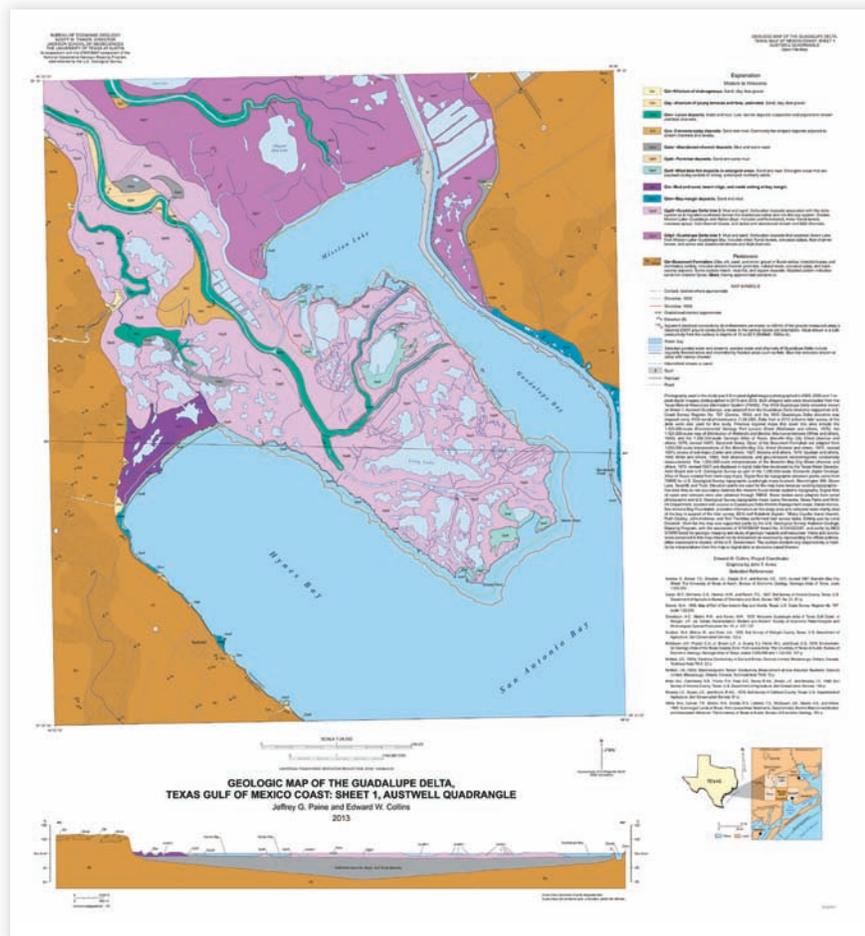
Nine geologic maps were produced during 2013. Five of the newly completed maps show parts of the Guadalupe delta and support ongoing

studies of shoreline changes and fluvial-deltaic deposition, providing baseline data to help in the management of this environmentally sensitive coastal area. Two maps in South-Central Texas, adjacent to the Eagle Ford Shale oil and gas play, support exploration for new sand and gravel resources for road construction and cement production, and for sands used as proppant for hydraulic fracturing. In Central Texas, a map was completed for part of the corridor northwest of Austin. Another map was completed for an area of North-Central Texas where sand and limestone are quarried to meet current demands. Researchers conducting geologic mapping for Bureau projects were Eddie Collins, Brent Elliott, Jeff Paine, and Chock Woodruff.

Texas agencies contribute to the process of identifying and prioritizing geologic map study areas. Scientists and managers of the Texas Water Development Board, General Land Office of Texas, Railroad Commission of Texas, Texas Parks and Wildlife Department, Texas Commission on Environmental Quality, and Texas Natural Resources Information System meet annually, together with scientists of Federal agencies such as the U.S. Geological Survey and the U.S. Fish and Wildlife Service.

Long-term goals for geologic mapping in Texas include gathering baseline map data along the Texas Gulf Coastal Plain Corridor, where there are some areas of environmental concern such as areas prone to erosion, flooding, and loss of sensitive coastal environments. These data will be used to create maps to help foster economic development of minerals/earth materials and manage potential geologic hazards. Detailed geologic maps within population/transportation corridors will be compiled in areas where growth is increasing demands on earth resources and ground water.

For more information:
<http://www.beg.utexas.edu/mapping/map01.htm>



The Water-Energy Nexus

Drought and the Water-Energy Nexus in Texas

In 2011, Texas experienced its most extreme drought on record, with record low precipitation and nearly 100 days of triple-digit temperatures, resulting in record electricity demand and historically low reservoir levels. In a study funded by the STARR program, Bureau researchers

Bridget Scanlon, Ian Duncan, and Bob Reedy quantified water and electricity demand and supply for each power plant during the drought. They found that,

relative to 2010, which was used as a baseline, the 2011 drought raised electricity demand (generation) by 6% and peak demand by 4%, increasing water demand (consumption) for electricity by 9%. Reductions in monitored reservoir storage to below 50% of capacity during the drought would seem to suggest drought vulnerability; however, the study showed that, at the power-plant level, the electrical generation system was flexible enough to adapt, primarily by switching to less-water-intensive technologies. Specifically, ~50% of Texas' power-plant fleet now uses natural gas as its fuel source. This change enhances drought resilience because natural gas-fueled combined-cycle generators require only ~30% of the cooling water needed by traditional

steam turbine plants fueled by coal. This change also leads to a substantial water savings and increases the flexibility of power-plant generators, which in turn tap into the increasing wind-generation capacity in the state. These reductions in water use are projected to continue until 2030, with increased use of natural gas and renewables. Although water use for gas production (for example, water used for hydraulic fracturing) is controversial, these data show that water saved by using natural-gas combined-cycle plants relative to coal/steam turbine plants is 25–50 times greater than the amount of water used in hydraulic fracturing to extract the gas. By looking at energy and water in the broader sense, Scanlon and her colleagues are providing a more comprehensive picture of how Texas is managing both of these vital resources.

For more information:
<http://www.beg.utexas.edu/water-energy/index.php>



Surface Casing Estimator Site

The Surface Casing Estimator Site, also referred to as the Estimator Site, is a website that provides estimates of the depths to ground-water horizons that may require borehole casing for ground-water protection in oil and gas wells. This project is funded by the Railroad Commission of Texas (RRC) and coordinated by the Commission's Groundwater Advisory Unit. Estimator Site values are not final regulatory values. The RRC Groundwater Advisory Unit determines and provides final recommendations for ground-water protection in required Surface Casing Letters. Bureau project personnel scan paper copies of geophysical

logs obtained from the Groundwater Advisory Unit's vast Q-log library to preserve these data as digital images; a representative number of Q-logs are available for viewing on the Estimator Site.

In addition to industry operators, other professionals interested in ground water may also find useful information on the Estimator Site. For example, the site provides estimates on elevations and depths for the top and base of fresh water (1,000 parts per million of total dissolved solids [TDS]), base of usable-quality water (3,000 TDS), base of underground sources of drinking water (10,000 TDS), and top and base

of some water-bearing stratigraphic units. The Estimator Site currently provides information for 49 Texas counties. More than 6,600 geophysical logs can currently be viewed on the website, including 1,340 new logs added in 2013.

Work during 2013 added estimates for 8 South Texas counties: Atascosa, Bee, DeWitt, Dimmit, Karnes, Maverick, Webb, and Wilson. Nearly 10,000 geophysical logs were also scanned for 12 counties. Bureau researchers on this project are Eddie Collins, Tom Tremblay, Aaron Averett, and Jeremy Ortuño.

For more information:
<http://www.beg.utexas.edu/sce/index.html>

Environmental Research & Hazard Mitigation

Carbon Injection and Monitoring at Cranfield, Mississippi

The year 2013 marked the fifth year of monitoring the large-volume CO₂ injection site at Cranfield, Mississippi. The project is part of the Southeast Regional Carbon Sequestration Partnership (SECARB), led by the

Southern States Energy Board and funded by the U.S. Department of Energy's National Energy Technology Laboratory (NETL). A

commercial enhanced-oil-recovery (EOR) site, operated by Denbury Onshore, LLC, has provided a location where Bureau staff and their international collaborators have fine-tuned processes for monitoring subsurface environments, to document that injected CO₂ is remaining where it is expected. To date, more than 4.5 million metric tons have been injected. Progress in 2013 included a new understanding of geomechanical processes on the basis of multilevel pressure gauges in the subsurface, assessment of airborne electromagnetic and gravity surveys for site characterization and potentially for



monitoring, and a new tracer-based monitoring method using an injection well as a monitoring point.

For more information:
<http://www.beg.utexas.edu/gccc/cranfield.php>



Gulf of Mexico Seismic Data-Collection Cruise

In October 2013, the Gulf Coast Carbon Center's Dr. Tip Meckel led a team of three UT scientists on a 10-day, 3D-seismic data-collection cruise off the Texas coast in the Gulf of Mexico. Among the 26 people on board, participants included the BEG's Dallas Dunlap, Dr. Nathan Bangs (Institute for Geophysics), and Ben Phrampus, a graduate student from Southern Methodist University. Logistical coordination from shore was led by the BEG's Ramón Treviño. The survey sailed on the *R/V Brooks McCall*, based out of Freeport, Texas, and operated by TDI-Brooks International,

Inc., of College Station. NCS SubSea provided navigation support. The survey was funded through NETL's carbon sequestration research program and the Texas General Land Office (GLO), as part of a multiyear effort to characterize potential CO₂ storage sites in the near-offshore Gulf of Mexico. This is the second survey using the BEG's new P-Cable seismic acquisition system (96 channels, 12 streamers), which provides extremely high-resolution 3D data for relatively shallow stratigraphic depths (<1500 m). The BEG is the only research institution in the country currently operating

such a 3D-seismic acquisition system. During the survey, over 400 line-km (> 250 miles) were shot offshore of southern Galveston Island, adjacent to and including portions of the San Luis Pass shallow salt dome. Survey goals were to image subsurface stratigraphy and structure above a Miocene-age CO₂-storage prospect at ~2,000 m depth in order to understand geologic seal and fluid systems. Data processing is ongoing, and one more Gulf of Mexico acquisition survey for this project is planned for 2014.



For more information:
<http://www.beg.utexas.edu/gccc/index.php>

Soil-Gas Monitoring for CO₂ Retention

Soil-gas monitoring is challenging because CO₂ in the near-surface is dynamic, can originate from many sources, and is commonly modified by a variety of natural processes; therefore, discerning natural environmental variation from a storage-formation leak is difficult. During the last few years, Bureau scientist Dr. Katherine Romanak (right) has been developing an innovative method to determine the source of CO₂ in near-surface sediments at geologic CO₂ storage sites. The *process-based method*, as it is called, is a simple but powerful new monitoring approach that uses geochemical ratios to detect CO₂ leaks promptly and accurately. Other field methods require years of background data collection and complex statistical

analyses to determine if CO₂ leakage is occurring. The process-based method was developed at a natural CO₂-rich playa lake and applied at an oilfield where deep gases migrated from depth into the near-surface. The method was further tested at the ZERT controlled-release site in Bozeman, Montana, and used in the Kerr Farm investigation in Saskatchewan, Canada, where landowners claimed CO₂ was leaking at a world-renowned carbon capture and storage (CCS) project (the IEAGHG Weyburn-Midale CO₂ Monitoring and Storage Project). Dr. Romanak's analysis showed that leakage from depth was not occurring at this site. The paradigm shift resulting in the method's successful use at onshore carbon storage sites has created



interest in additional applications: for example, seafloor sediments above offshore carbon storage sites and in unconventional shale gas and coalbed methane operations.

For more information:
<http://www.beg.utexas.edu/gcc/index.php>

Texas Water Resources and Endangered Aquatic Species

The Bureau's Dr. Brad Wolaver has been studying whether and how the listing of aquatic species as endangered would affect Texas water resources. In 2013, in collaboration with the Texas Comptroller of Public Accounts and the Interagency Task Force on Economic Growth and Endangered Species, Wolaver and others at the BEG completed a study that estimated

potential economic impacts of changes in water availability that would result from a possible Federal listing of five Central Texas freshwater

mussels (left) as threatened or endangered. These mussels are found in the Brazos, Colorado, and Guadalupe-San Antonio River basins—a broad and highly populated swath of the state. The presence of endangered species would require a certain amount of water to flow through these rivers even in times of drought, potentially reducing withdrawals for human use. Therefore, a Federal listing of these aquatic species could impose a significant cost in economic terms.

Wolaver and his team projected reductions in water supply to power plants and to the commercial, industrial, municipal, and agricultural sectors if the mussels were listed. Economic impacts were then assessed with collaborators from the University of California, Berkeley, and California

Polytechnic State University. The results were surprising, projecting the economic impact to be smaller than initially anticipated. However, arid parts of West and Central Texas that already experience water-supply challenges would see additional water-supply reductions—particularly during droughts, when supplies are tight. As a result, the Bureau recommended that Texas implement several innovative water-management strategies, including water markets, conjunctive use of surface water and ground water, and aquifer storage and recovery to provide water-supply buffers. Many of these approaches, which are included in the State Water Plan, will be implemented as part of the current State Water Implementation Fund for Texas (SWIFT) process. A peer-reviewed paper on this topic will be published in Spring 2014 in the *Journal of the American Water Resources Association*.

For more information:
<http://www.beg.utexas.edu/gcc/index.php>

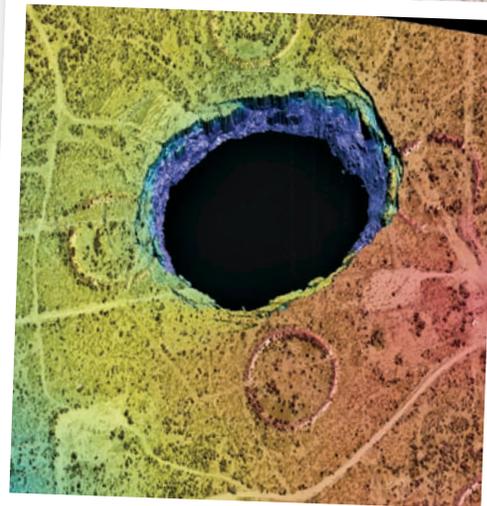


Wink Sinkholes Research

Since the collapse of Wink Sink 1 in 1980, Bureau researchers have periodically studied the collapse of that sinkhole, the subsequent collapse of Wink Sink 2 in 2002, and evidence of land instability and ground movement in the Wink and Kermit area in West Texas. Recent Bureau work near Wink found current rates of subsidence of as much as 1 ft/yr locally. Follow-on microgravity surveys near the sinkholes suggested the presence of mass deficits in the shallow subsurface beneath subsiding areas, indicating rock cavities and the potential for continued subsidence. In 2013, the Bureau conducted further activities, including an update of satellite-based measurements of recent (post-2008) subsidence in the area using InSAR (interferometric synthetic aperture

radar) and an airborne lidar survey using the Bureau's new Chiroptera system. These results were used to create a baseline high-resolution topographic model of the area and to identify areas that have undergone significant topographic change since the lower-resolution topographic survey of the area was conducted in the 1960's. These data are currently being analyzed and will be presented at a conference in early 2014.

For more information:
<http://www.beg.utexas.edu/nso/winksink.php>

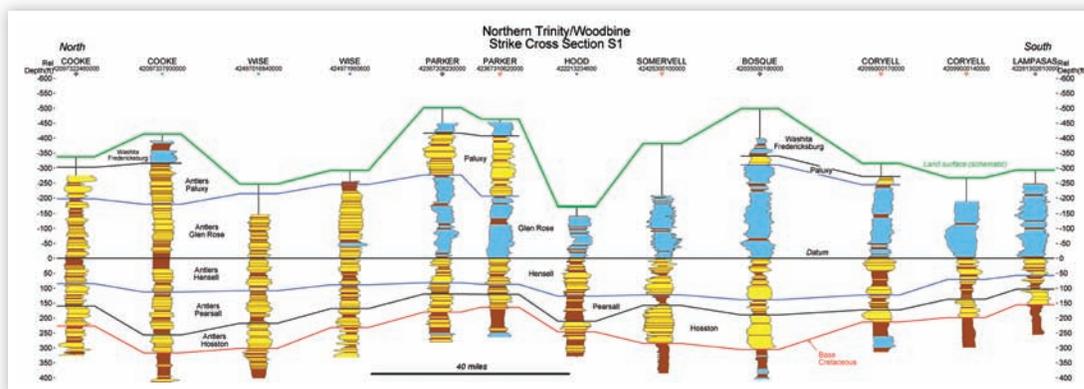


Ground-Water Aquifer Stratigraphy

Because ground-water resources are as important as oil and gas to the future of Texas, ground-water aquifers should be characterized and mapped with the same level of scientific expertise and effort as are petroleum reservoirs. To that end the Texas Water Development Board and a consortium of ground-water conservation districts in Texas awarded Dr. Scott Hamlin two significant contracts to develop stratigraphic frameworks for major Texas aquifers in support of ground-water resource modeling; the subjects of the contracts are Cretaceous aquifers in North-Central Texas

and High Plains aquifers in West Texas. Success in securing these awards was due in part to earlier research by Dr. Seay Nance, whose work in this area is well known. Hamlin and Nance employ modern stratigraphic methods and depositional-systems analysis, which are common in petroleum reservoir

studies but have not been widely used in ground-water studies. Aquifer sandstones are mapped in detail using closely spaced geophysical logs from oil and gas tests. Thus, an added benefit from petroleum exploration in Texas is the abundance of subsurface data provided by geophysical well logs. Hamlin and Nance use the shallower intervals of these logs to determine both lithology of the aquifer matrix and quality of ground water within the aquifer pore system.



Resources for the Public

Core and Sample Repositories

The recent surge in interest in unconventional oil and gas plays has created a corresponding surge in interest in the cores and cuttings housed at all three Bureau core repositories (in Austin, Midland, and Houston). These repositories house more than 2 million boxes of cuttings and cores from around the United States, and all of the material is available publicly and searchable online.



Why have the repositories become so critical to unlocking the potential of the vast resources recently discovered? The answer lies in the scientific data that can be generated from analysis of the rocks themselves—data that can be critical to determining whether or not oil and gas are present in an area.

Take, for example, the Eagle Ford Shale play, which has boosted U.S. oil and gas production significantly and transformed South Texas. Several years ago, Gregg Robertson, an independent geologist in Texas, had a hypothesis that the Eagle Ford Shale might be capable of producing vast quantities of oil and gas over a huge geographic area. However, he needed samples from thousands of feet under the South Texas soil to prove that the rocks had the right physical and chemical properties. So, in 2008, he turned to the BEG and found that the Austin Core Research Center housed samples from an old Phillips well in La Salle County. The samples were analyzed and were found to contain exactly what

Robertson and his partner company Petrohawk had hoped for—the rocks were “right”! The Eagle Ford is now a leading U.S. oil-producing region and has helped turn around Texas and U.S. oil production. It all starts with the rocks.



In 2014, the Bureau is starting a new project intended to provide a new way of conveying the subsurface geospatial locations of the cores, cuttings, and well logs by referencing them to well-known stratigraphic and geologic surfaces. The project requires updating the current data base, modeling the subsurface extent of reference stratigraphic units across the state of Texas, and combining these data into a simple, graphical, Web-accessible user interface.

For more information:
<http://www.beg.utexas.edu/facilities.php>

Geophysical Log Facility

Careful calibration between rock material and geophysical cores is crucial to understanding the real story about the rocks beneath our feet. In addition to our core and sample repositories in Austin, Midland, and Houston, the BEG operates the Geophysical Log Facility (GLF), located at the Austin BEG campus. The GLF houses approximately

1.5 million geophysical logs from hundreds of thousands of oil and gas wells drilled in the State of Texas. All log material is available to the public, and patrons may search for logged wells on BEG’s online data base.

Geophysical logs are records of the data acquired by tools sent down the borehole after the

drilling of a well. Data include measurements of resistivity, acoustic properties, density, and radioactivity of the rocks encountered by the wellbore, extending from the surface down to tens of thousands of feet below the Earth’s surface. Geoscientists utilize the geophysical logs to predict where accumulations of oil and gas might be.

For more information:
http://www.beg.utexas.edu/info/glf_facil.php

Assisting the General Public

EarthSky

In response to guidance from the Bureau's Visiting Committee that more focus should be placed on getting the scientific message of the BEG out to the general public, Bureau researchers sat down with the editors of *EarthSky* for a series of public interviews.

EarthSky, formerly a public-radio program, is now a successful Web-based outlet for science news. The *EarthSky* broadcast network consists of more than 1,200 outlets across the United States and the world. Its audio programs are heard approximately 4 million times each day in the United States alone. Interviews posted on its website generally attract more than 100,000 unique visitors.

The 11 BEG scientists and interview topics included the following:

1. Susan Hovorka: Carbon capture and storage
2. Scott Tinker: Past, present, and future of energy
3. Eric Potter: The what, how, and why of hydraulic fracturing
4. Bridget Scanlon: Groundwater depletion and solutions
5. Lesli Wood: Exploring Gulf of Mexico deep-water oil
6. Ian Duncan: The environmental impact of fracking
7. Jeffrey Paine: Retreating shoreline along the Texas Gulf Coast
8. Michael Young: Water resources in Texas
9. Jay Kipper and Sean Murphy: Nanotechnology in oil and gas production
10. Chris Zahm: Understanding and probing the world below our feet



11. Bob Hardage: Using seismic technologies in oil and gas exploration

The Bureau received numerous positive comments on these segments. The *EarthSky* interviews were only the first in a series of actions designed to inform the general public about the Bureau's mission and ongoing research.

For more information:
<http://earthsky.org/tag/interviews>

Upcoming Geology of Texas Book and Website

In its role as the state survey and authority on Texas geology, the Bureau has begun developing a book and companion website to help the public understand and better appreciate the geology, landscapes, and resources of Texas.



The book will tell the story of Texas' earth history from earliest times to the present, linking the geologic underpinnings to the landscapes, soils, and historical development of the state. Specific chapters will focus on the abundant oil and gas, water, and mineral resources Texas is known for and on geologic hazards and other concerns. This narrative will dig deep into the history of Texas geology and also give readers some insight into how geologists put the pieces together.

The accompanying website will allow viewers to experience Texas geology

through a series called "Great Places," which profile the finest examples of accessible geologic sites across the state. The website complements the book with user-friendly geologic guides, key maps and cross sections, and interactive elements. The book and website will also suggest locations where travelers may see the geology for themselves.

The book, *Texas Through Time: Lone Star Geology, Landscapes, and Resources*, by Tom Ewing and Heather Christensen, will be published in Summer 2015 and will also be available in e-book format.

For more information:
<http://www.beg.utexas.edu/GeoTX/book.html>



Shaping the Global Energy Discussion

Launched in 2012, the *SWITCH* Energy Project really took off in 2013. The Project's foundation is the award-winning documentary film on global energy, *SWITCH*, now viewed by 3 million people. Its website, education initiatives, and social-media presence have reached millions more viewers around the globe. Led by Bureau Director, and the film's host, Scott Tinker and producer-director Harry Lynch, the *SWITCH* Energy Project promises to drive discussion about the world's energy for many years to come.

The concept for *SWITCH* originated from the desire to show people what our energy future might look like by producing an unbiased and carefully researched film. *SWITCH* explores the major sources of energy in the world and projects when humanity might reasonably be able to transition from coal and oil to alternative energy options.

The film took more than 3 years to complete. The production crew's odyssey took them to 11 countries and 26 major energy-producing sites. The crew interviewed more than 50 key people, from government experts and leaders to plant managers and corporate executives.

In the film, each energy resource is carefully assessed using four criteria: Is the resource available where people live and when they need it? Is it affordable? Is it reliable? Is it environmentally sustainable?

SWITCH also underlines how each of us can make a difference in our planet's energy future by deploying vital energy-efficiency measures right now.

SWITCH is a beautiful and thought-provoking documentary that includes Dr. Tinker's analysis of when the energy transition might one day occur. The film has generated wide debate from both ends of the energy spectrum, fulfilling one of the Project's main objectives: bringing people together and fostering dialogue about energy in what Dr. Tinker has dubbed "the radical middle."

As of the end of 2013, *SWITCH* has been screened in theaters worldwide more than 800 times, including over 400 screenings on university campuses. The website <http://www.switchenergyproject.com/>



Service



has had over 150,000 visitors; almost 12,000 people have become Facebook fans or Twitter followers; and thousands of educators across the U.S. are using some aspect of *SWITCH* in their science, engineering, and energy courses. Watch for a new video series in 2014 called the *SWITCH* Energy Lab, which will include videos and curriculum for primary-school STEM (science, technology, engineering, and mathematics) students and nonscience college students.

For more information: <http://www.switchenergyproject.com/experts/Scott-Tinker>

BEGstore: Official Store of the Bureau of Economic Geology

With both a brick-and-mortar and an online presence, BEGstore is the official store of the Bureau of Economic Geology.

The bookstore serves the geoscience community, educators, and the general public with more than

1,900 books, maps, and digital media produced by the staff of the Bureau of Economic Geology. The store also sells publications issued by UT's Texas Memorial Museum, the Gulf Coast Association of Geological Societies (GCAGS) and several of its member geological societies, and the Gulf Coast Section of SEPM (GCSSEPM). The BEGstore supports and informs teachers and the public with guide-books, maps, and other resources



such as the popular Central Texas Rock Kit, which has been reaching classrooms statewide since the 1990's. Approximately 3,000 Rock Kits were distributed across the state in 2013 alone.

For more information: <http://begstore.beg.utexas.edu/store/>



Education and Outreach

Public outreach to Texas citizens is a key part of the Bureau's mission. The Bureau sustains public outreach programs through its Resource Center, which is open weekdays from 8:00 a.m. to 5:00 p.m. and includes the Public Information Office, the BEGstore, the Geophysical Log Facility (GLF), the Map Room, and the Texana Library.

In 2013, education and outreach activities included presentations and onsite tours for professional groups, educators, community-service

organizations, scouts, and school groups. Additional activities included service on the Texas Groundwater Protection Committee Public Education and Outreach subcommittee and the promotion of water-resource stewardship through the Protect Your Groundwater Day campaign. In support of geoscience education in Texas schools, Scott Rodgers and Linda Ruiz McCall distributed more than 750 maps, Rock Kits, information sheets, and links to online resources to

science teachers from around the state at the Conference for the Advancement of Science Teaching. Ruiz McCall presented to educator workshops for the Groundwater to the Gulf Institute in Austin, the Project Wild Aquatic at the Perot Museum in Dallas, and the Texas Earth Science Teachers Association in Houston. She also spoke to the El Camino Real Chapter of the Texas Master Naturalists about ground-water/surface-water interactions, and assisted the Hill Country Science Mill Museum in planning a new water exhibit.

For more information:
http://www.beg.utexas.edu/info/res_ctr.php



Developing Future Scientists

GeoFORCE Texas



GeoFORCE Texas is a pre-college program at the Jackson School of Geosciences, providing hands-on science learning experiences for high-school students from rural southwest Texas, inner-city Houston, and the North Slope of Alaska. GeoFORCE is a public/private partnership, receiving its funding from private industry, foundations, state and federal government, and individual donors.

The goal of the GeoFORCE program is to encourage a diverse group of youth from underserved schools to excel in the sciences and pursue higher education in scientific fields.

In 2013, GeoFORCE took 594 high-school students on field trips to study geology and supported 475 college students, graduates of GeoFORCE, on their path to college graduation. The first GeoFORCE cohort started participating as rising 9th graders in 2005. Now 4 years out of high school, GeoFORCE alumni have begun graduating from college. Four such alumni received their B.S. degrees in Geology and Geophysics from UT Austin and UT San Antonio.

GeoFORCE students continue to exceed expectations. These students

have achieved a 100 percent high-school graduation rate. An impressive 96 percent of GeoFORCE students go directly to college and 94 percent of students return for their second year. These numbers are substantially higher than national averages. GeoFORCE graduates are also studying in STEM (science, technology, engineering, and mathematics) fields in much higher numbers than the national average. As of Fall 2013, 64 percent of GeoFORCE grads are STEM majors, including 70 geoscience majors and 54 engineers. GeoFORCE received national recognition in 2013: the National Academy of Sciences published two reports that featured GeoFORCE as an exemplary program. Last summer, four BEG scientists—Peter Flaig, Greg Frébourg, Linda Ruiz McCall, and Jeff Paine—served as instructors during the summer events.

For more information:
<http://www.jsg.utexas.edu/geoforce/>

Texas High School Coastal Monitoring Program

The Texas High School Coastal Monitoring Program (THSCMP), a research and outreach project led by Tiffany Caudle, is designed to help coastal residents develop a better understanding of dune-and-beach dynamics on the Texas coast. The program focuses on high-school and middle-school students and teachers, training them to measure topography, map vegetation lines and shorelines, and observe weather and wave conditions. THSCMP is now in its 17th year of operation, with seven schools participating. As active

participants in an actual research project, students enhance their science education and provide coastal communities with valuable data on their changing shorelines.

BEG researchers and students make at least three field trips per year to survey sites in each region, including Galveston Island, Matagorda Peninsula, Mustang Island, North Padre Island, and South Padre Island. Students at these coastal schools conduct scientific studies and share their observations with other students, schools, and, via the

Internet, the public. Data are used by decisionmakers to address coastal issues and eventually appear in a scientific publication.

For more information:
<http://www.beg.utexas.edu/coastal/>



3D Outreach

Because the Bureau has a dual responsibility—to conduct innovative earth science research and to serve as the geological survey for the State of Texas—educational and professional outreach is a central part of our mission. In support of this mission, the Bureau has a long history of developing and presenting custom 3D presentations to showcase various research programs and initiatives. From Martian deltas to the Edwards aquifer to domestic and international petroleum reservoirs, Bureau researchers have created dozens of compelling, immersive 3D presentations for students, lawmakers, industry partners, government agencies, and fellow scientists. Although some of these projects can either be viewed online or downloaded and run locally, most are designed to be projected onto a large screen and viewed with 3D glasses.

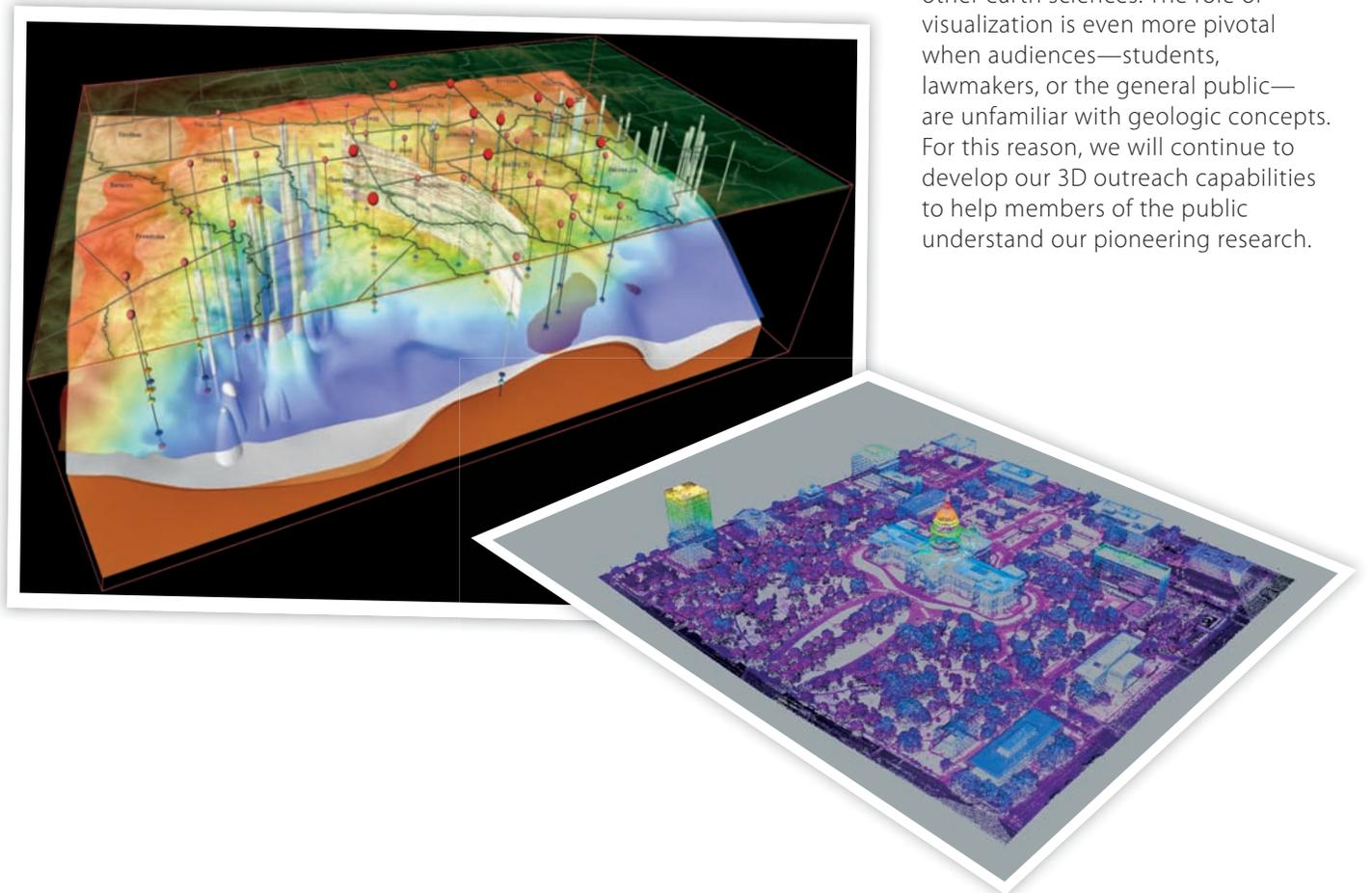
These 3D presentations are often shown at the Bureau, but the whole system—computer, projectors, and screen—is portable and can be easily reassembled off-site to bring Bureau research to schools, conferences, and other venues.

In 2013, the Bureau's 3D outreach program offered more than 100 formal presentations. As in many past years, the Bureau participated in Earth Science Week in October, with multiple 3D presentations to Central Texas middle-school students. The Bureau is likewise committed to the Jackson School's GeoFORCE program and presented many 3D projects to participating high-school students in Uvalde during the summer. In addition to these two events, the Bureau's 3D crew, including Linda Ruiz McCall, Reuben Reyes, Dallas Dunlap, John Andrews, and Joseph Yeh, organized presentations both

in-house and off-site for students at Saegert Elementary School (Killeen), Rouse High School (Leander), Bedichek Middle School (Austin), Bastrop High School, and Austin Community College. We also regularly present to current and prospective Jackson School students as well as to interested members of the general public, including members of the Wichita Falls Desk & Derrick Club, who visited in October.

Professional outreach is no less important to us than educational outreach, and in 2013 we presented our 3D work on numerous occasions to colleagues in the earth science community at both informal meetings in-house and professional meetings, including the West Texas Geological Society's annual symposium in September and the annual meeting of the Reservoir Characterization Research Laboratory (RCRL) in October.

Visualizing complex geological structures and processes in 3D and 4D is critical to our ever-evolving understanding of geology and other earth sciences. The role of visualization is even more pivotal when audiences—students, lawmakers, or the general public—are unfamiliar with geologic concepts. For this reason, we will continue to develop our 3D outreach capabilities to help members of the public understand our pioneering research.



Explore UT



On March 2, 2013, The University of Texas at Austin once again hosted 50,000+ attendees at the 2013 Explore UT open house. Members of Bureau staff presented elementary-, middle-, and high-school students and their parents with engaging and thought-provoking activities. Interactive activities presented by Gulf Coast Carbon Center staff and students (Julie Ditkof, Mary Hingst, Susan Hovorka, Zahid Khandaker, Jiemin Lu, Ramón Treviño,

Wylie Walker, and Kerstan Wallace) included building models of carbon dioxide molecules, floating balloons on a bed of invisible carbon dioxide, and exploring a magnified model of reservoir pore space. Mark Blount, Jan Braboy, Melissa Garcia, Tessa Green, Emily Hooks, Susan Horvath, Kim LaValley, Chris Parker, Eric Potter, Phyllis Potter, Patty Romano, and Valerie Siewert treated participants to the excitement of panning for gold (well, pyrite) with the "Find Gold" activity.



For more information: <http://www.utexas.edu/events/exploreut/>

Earth Science Career Day

The 14th Annual Austin Earth Science Week (ESW) Career Day was held on October 11, 2013, at the Commons Learning Center. The event drew 250 middle-school students and their teachers from the Austin area, who learned about the exciting and varied careers in geoscience. Linda Ruiz McCall organized the day, which included contributions by a host of Bureau researchers and staff. More

than 70 earth science professionals volunteered their time to participate as presenters, exhibitors, and tour guides. Special thanks go out to the Lower Colorado River Authority Employees' United Charities, Statoil, the Subsurface Library of Midland, and the UT Jackson School of Geosciences Friends and Alumni Network for

joining the Bureau of Economic Geology in providing the financial support for the event. In-kind sponsors included Allan R. Standen LLC, Austin Community College, the Austin Geological Society, the Austin Planetarium, the City of Austin Watershed Protection Department, Houghton Mifflin Harcourt, the Paleontological Society of Austin, the Texas Commission on Environmental Quality, the Texas Water Development Board, the UT Center for Space Research, the UT Institute for Geophysics, and the UT Jackson School of Geosciences GeoFORCE Program.

For more information: <http://www.beg.utexas.edu/esw/careerday.htm>



Highlights Include:

- ▶ Grants & Funding
- ▶ Meetings, Programs, & Events

Grants & Funding

RPSEA Grant for Bureau Researchers

The Bureau's J.-P. Nicot, Bridget Scanlon, and Ian Duncan have been awarded a substantial grant by the Research Partnership to Secure Energy for America (RPSEA) for their project titled "Understanding and Managing Roadblocks to Shale Gas Development Related to Groundwater Contamination from Gas, NORMs, and Trace Metals (Texas)." The 2-year study aims to enhance understanding of naturally occurring shallow gas—either dissolved or free phase—to facilitate rational analysis of possible contamination of ground water with gas, trace metals, and naturally

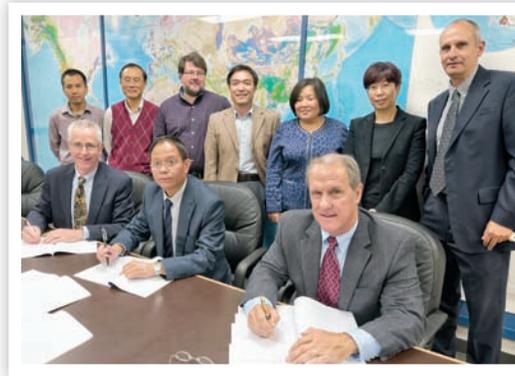
occurring radioactive materials (NORMs). The project also seeks to discover the nature and variability of flowback in order to adjust and optimize flowback treatment and possibly fracturing-fluid composition. This research will be used to develop a best-management-practice manual for baseline monitoring and fingerprinting of sources and processes affecting shallow gas. The study will apply state-of-the-art chemical and isotopic approaches in gas and water to fingerprint sources of gas and mobilization mechanisms of chemical species



from shales. The team will develop methods to distinguish gas sources and processes affecting ground-water contamination with gas, trace metals, and NORMs. Nicot (left) will serve as managing principal investigator for the project, and Scanlon (middle) and Duncan (right) will be co-PI's. Other key Bureau researchers working on this project include Pat Mickler, Changbing Yang, Katherine Romanak, and Jiemin Lu.

Yanchang Petroleum Signs Major Agreement with BEG

On November 8, a team of executives from Shaanxi Yanchang Petroleum Company, Ltd., visited the Bureau of Economic Geology to sign a \$1 million, 2-year agreement to investigate various exploration properties of lacustrine shale formations in the Shaanxi Province of China. Chief in the negotiations with Yanchang was Bureau organic geochemist and geologist Tongwei Zhang, who will also lead the gas geochemistry portion of the study as co-principal investigator. Zhang pointed out, "Yanchang searched the U.S. for the right group of researchers. They think BEG has a very good integrated team with talented researchers who publish great papers." He pledged, "We are going to try to demonstrate our abilities." Also on the BEG team are co-principal investigator Hongliu Zeng and Kitty Milliken, Steve Ruppel, Bob Loucks, Harry Rowe, and Sheng Peng, each spearheading a different research effort under the agreement.



The Bureau's contacts with China extend back to the 1990's, when a number of visiting scientists from China began joining the Bureau staff, leading to growing ties to the Chinese petroleum industry and its supporting training organizations. The first Bureau trip to China took place in 2004, when a BEG team, led by Director Scott Tinker and Associate Director Jay Kipper, visited Chinese companies and educational institutions to spread the word about Bureau research and to make new friends. Since then, Bureau researchers have traveled frequently to China to conduct research, exchange ideas, teach

classes, present at conferences, and offer technical expertise. A dozen individual research projects at the Bureau have received funding from various large Chinese oil and gas companies during the past 10 years, although none have been of the magnitude of the new Yanchang initiative.

"We're very excited about this new partnership with Shaanxi Yanchang Petroleum," said Eric Potter, Associate Director of BEG's energy division. "It gives us a unique opportunity to conduct research in areas where we have technical strengths. The experience we gain from this extensive relationship, investigating rock properties and reservoir characteristics we've never seen before, will be invaluable."

"It takes a very motivated scientist to want to conduct research half a world away," added co-principal investigator Hongliu Zeng. "We are very fortunate to have those kinds of motivated people on our team, and the opportunity to conduct important research in China at a high level."

Meetings, Programs, & Events

U.S. Department of Energy Officials Visit the Bureau

On February 19, Christopher Smith, then Acting Assistant Secretary for Fossil Energy at the U.S. Department of Energy (DOE), and Anthony Cugini, Director of the DOE's National Energy Technology Laboratory (NETL), visited the Bureau for a day of discussions and presentations on energy and environmental research. Both Federal policymakers received a briefing by Director Scott Tinker on research at the Bureau and then listened to presentations by researchers on current Bureau work, including a review of rock-fluid interaction at the Gas Geochemistry Lab by Pat Mickler, a tour of the Nanogeoscience Lab by Farzam Javadpour, a look at results using the field emission scanning electron microscope by Rob Reed, a tour of the Core Research Center (CRC) by Bill Ambrose, an overview of ongoing CO₂



From left: Christopher Smith, then Acting Assistant Secretary for Fossil Energy at the Department of Energy (DOE); Anthony Cugini, Director of the DOE's National Energy Technology Laboratory (NETL); and Scott Tinker, BEG Director.

research programs by Susan Hovorka, and a look at unconventional-resource production by Steve Laubach. Dr. Tinker concluded with an overview of the Sloan Shale Gas

Assessment Study. A brief reception afforded Smith and Cugini the opportunity to meet several Bureau students and other researchers.

BEG Hosts Industry Day 2013

On March 22, Industry Day 2013 showcased the Bureau's researchers, students, and facilities at the

Core Research Center. More than 100 invited guests, including industry and government leaders and decision-makers, toured the facilities, saw poster presentations covering the breadth of Bureau research, and met with student researchers. Visitors also heard talks by Bill Mullican of the Texas Water Development Board and Gregg Robertson, geologist and "Father of the Eagle Ford Shale." Associate Director Michael Young, J.-P. Nicot, and Bridget Scanlon hosted a discussion exploring the potential for a new and timely Water-Energy Consortium.

This year's theme was "The Confluence of Energy and Environmental Research," and participants were able to learn about all of the Bureau's industrial consortia and key programs.



Bill Mullican, Texas Water Development Board Director for Water Resources Planning, discusses water management.



From left: CRC's James Donnelly, Gregg Robertson, Scott Tinker, and Eric Potter

BEG Houston Research Center Hosts CoreFest

The Houston Research Center (HRC) 10th Anniversary Celebration and CoreFest, held on May 9th, was a resounding success. Dozens of industry representatives and HRC supporters enjoyed an afternoon of viewing the extensive repository

of cores, cuttings, and well material accessible at the HRC; touring the vast core warehouse; listening to presentations on the value to oil and gas exploration of maintaining a core repository; learning about new technologies for core analysis; and

watching a screening of the energy documentary *SWITCH*. BEG Director Scott Tinker honored the many past donors to the HRC, including major contributors BP, Chevron, ConocoPhillips, and Occidental Petroleum.



AEC Establishes Cutting-Edge Nanotechnology Lab

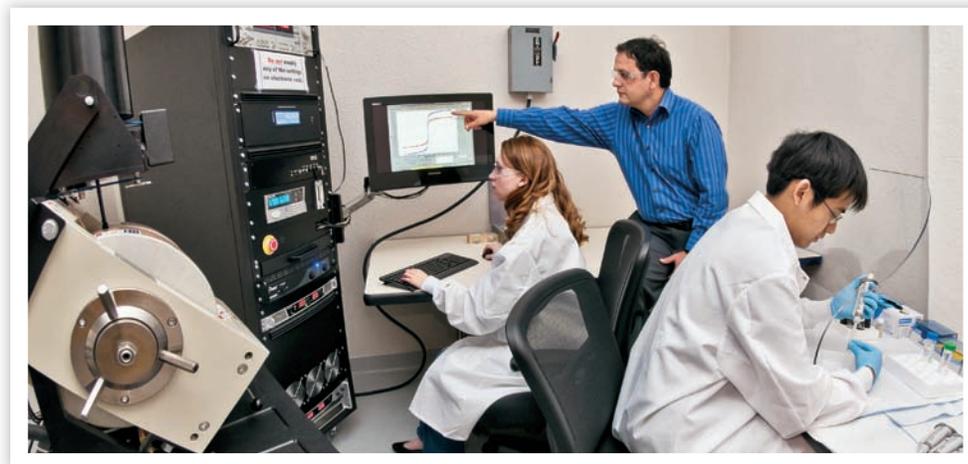
The Advanced Energy Consortium (AEC) has established a nanotechnology laboratory at the Bureau's Core Research Center (CRC) and is undertaking an extensive metrology study to compare and

The CRC's Contrast Agent Program aims to synthesize and characterize various nanoparticles (including MNP's) that will be used for illumination of subsurface reservoirs fluids. The immediate need is to

nanoparticles to determine the relationship between their physical and chemical characteristics (composition, size, crystallinity, surface coating, and so on) and their magnetic permeability. Through

generous grants from AEC member companies and matching funding from the Jackson School of Geosciences (JSG) Equipment Fund, the lab has purchased a vibrating sample magnetometer (VSM). Until now, AEC has relied upon a superconducting quantum interference device (SQUID) for measurement of magnetic properties of nanoparticles. However, the relatively low throughput and high costs associated with SQUID limited the number of samples that could be measured. In

comparison, the VSM promises a much higher throughput (about six times that of SQUID) and is suitable for detailed analysis of magnetic characteristics of nanoparticles. The availability of the VSM at the BEG will extend AEC's suite of nanogeoscience tools and encourage new collaborative research and training opportunities for JSG students and research staff in the areas of nanogeosciences, magnetics, paleomagnetism, and metrology.



Dr. Mohsen Ahmadian (center) and staff in the nanotechnology lab

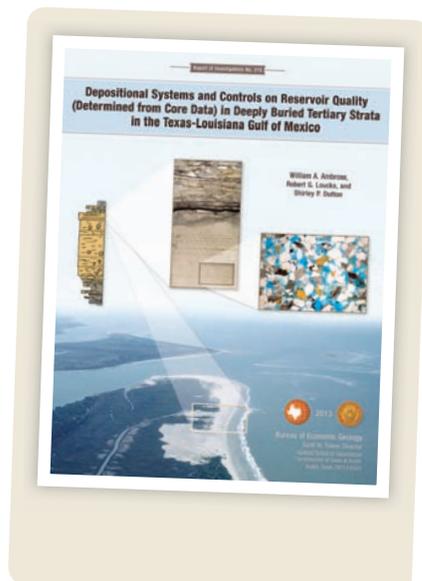
catalog magnetic nanoparticles (MNP's) for their usefulness in illuminating waterflood and fracture-network imaging. The lab and project are managed by Dr. Mohsen Ahmadian, and the team's research is being conducted in collaboration with scientists at leading universities in the United States, Europe, and South America and at member companies including BG, BP, Petrobras, Schlumberger, Shell, Statoil, and Total.

assess the usefulness of MNP's as passive tracers traversing the injected-waterflood front. These tracers could then be imaged using existing electromagnetic cross-well geophysical tools in order to improve the resolution and depth of investigation beyond those of current logging techniques. The nanometrology lab was established to expedite characterization of various MNP contrast agents being synthesized. Its mission is to analyze

Deep Shelf Gas Publishes Report of Investigations No. 278

Research conducted during the Bureau's Deep Shelf Gas project was published this year in BEG Report of Investigations No. 278. The RI, authored by Bill Ambrose, Bob Loucks, and Shirley Dutton, is titled *Depositional Systems and Controls on Reservoir Quality (Determined from Core Data) in Deeply Buried Tertiary Strata in the Texas-Louisiana Gulf of Mexico*. As summarized in this

report, study of cores from onshore Texas and Louisiana provides insight into the factors that control reservoir quality in deep exploration targets below the Gulf of Mexico shelf and in deep water. This work demonstrates that relative position within the sequence-stratigraphic framework and facies tract can exert powerful controls on reservoir quality, even in deeply buried successions.



Center for Energy Economics Predicts Increased Natural Gas Demand



During 2013, the BEG's Center for Energy Economics (CEE)

focused its research mainly on the midstream sector (pipelines, storage, processing, and other aspects of critical infrastructure) and U.S. industrial demand for oil and gas. This research, sponsored by industry and government, provides an independent assessment of the key factors affecting deliverability and consumption of oil and gas production.

Major conclusions and outputs were presented and discussed at CEE's 2013 annual meeting on December 4–5, and included the following:

- ▶ CEE estimates that natural gas fractionation—an important component for continuing drilling and development of liquids-rich plays, especially in new unconventional plays—will increase

to roughly 2.8 million barrels per day of capacity by 2015. This is almost a tripling of existing capacity.

- ▶ Although midstream businesses clearly are responding to market signals with new investments, many factors continue to impinge on oil and gas pipeline and other capacity additions, with implications for energy costs and price volatility.
- ▶ CEE has built a list of petrochemical and other industrial projects that, in the most optimistic case, could raise U.S. industrial natural gas demand to about 23 billion cubic feet per day by 2020. The bulk of this investment, about \$100 billion, would be directed to the U.S. Gulf Coast region. CEE researchers are continuing to track and monitor project developments while analyzing economic implications.

CEE's findings on oil and gas market developments are widely accessed by audiences seeking analysis of U.S. domestic production, emerging

trends, and the interconnections between government policies and global supply-and-demand balances. These audiences include researchers, U.S. and foreign government agencies, and nongovernmental organizations such as the Paris-based International Energy Agency.

In 2013, CEE researchers continued their analysis of electric-power market issues and modeling, investigating developments both in Texas and nationwide and demonstrating the potential growth of natural gas for electric-power generation as old power plants are retired, new plants are built, and the industry responds to potential new environmental rules. Findings on electric-power generation capacity to meet growing demand in Texas have been filed with the Public Utility Commission of Texas. CEE publishes early releases of working papers and other results on its "Think Corner" page: www.beg.utexas.edu/energyecon/thinkcorner

GeoFluids: Cutting-Edge Equipment Measures Shale Permeability

The UT GeoFluids team has developed the ability to measure shale permeability at the nanodarcy scale. This new, state-of-the-art laboratory apparatus (right) uses pulse-decay and steady-state techniques, and includes high-precision plumbing and valves, high-pressure pumps, pressure transducers, and a core holder, along with advanced temperature-control and data-acquisition systems. Researchers measure shale permeability under reservoir-pore and confining-pressure conditions. These experimental capabilities have been carefully tested and validated against independent standards and third-party measurements. Measurements carried out using this equipment are providing invaluable data on the constraints on permeability, permeability anisotropy, stress dependence of permeability,



and multiscale permeability behavior. The goal of the team is to predict porosity (storage) and permeability (flow) behavior in shales through the production life cycle in the hope that this understanding will

illuminate basic flow processes in shale and lead to more efficient production strategies. This work has been supported by Shell through the SUTUR initiative: <http://www.beg.utexas.edu/sutur/>

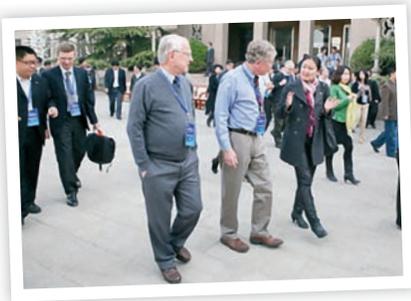
BEG Co-Sponsors Beijing Symposium

Eric Potter, Hongliu Zeng, Bob Loucks, and Steve Ruppel made presentations at the International Symposium on Theoretical Advancement and Technology Innovation for Emerging Energy Hydrocarbon Systems Resources (TATIEER): Deep and Unconventional Resources, in Beijing, China, on April 13–14. The event was hosted by RIPED, the research component of

PetroChina, at their large campus near downtown Beijing. The BEG co-sponsored the event, which was attended by 300 people, including Chinese researchers, explorationists, and students, as well as delegates from the Commonwealth Scientific and Industrial Research Organisation (CSIRO), North Queensland University, representatives of international energy companies, and the BEG delegation. Several members of the Chinese Academy of Sciences were honorary attendees. The talks featured updates on unconventional



resource development in China, including the many volcanic-reservoir plays characteristic of the rifting phase of many Chinese basins. RIPED capped the event with a laboratory tour showcasing significant equipment additions related to shale reservoir characterization.



Foss Takes Lead Role at LNG 17 Conference

On April 17, CEE’s Dr. Michelle Michot Foss (right) served on the International Program Committee and co-chaired the panel “Role of LNG in Growing Global Gas Demand” at the LNG 17 conference and exhibition in Houston. The LNG 17 event, a major triennial program held by and for the liquefied natural gas industry, brought together more than 5,000 professionals from more than

80 countries in the areas of industry, government, research, and consulting. The conference focused on a wide range of strategic, commercial, and regulatory issues surrounding LNG (liquefied natural gas), including the regulatory environment in importing and exporting countries, supply-and-demand management issues, and evolving major markets such as transportation.



Laubach Serves as Theme Chair at First URTeC

Stephen Laubach was selected as one of the Theme Chairs for the inaugural Unconventional Resources Technology Conference (URTeC) in Denver on August 12–13. URTeC is a science-driven event and a collaboration among three of the largest professional energy resource science societies in the world: SPE (Society of Petroleum Engineers), AAPG (American Association of

Petroleum Geologists), and SEG (Society of Exploration Geophysicists). The goal of the URTeC conference is to encourage collaborative, cross-discipline education and research across the entire range of technical backgrounds in energy exploration and production. Laubach served as chair for the theme *Fracture Characterization*, which included the following research



topics: Evaluating Fractures in Thin Section and SEM, Importance of Natural Fractures in Tight Reservoirs, Anisotropy of Fractured and Layered Systems, Hydraulic Fracture Modeling and Prediction, and Stimulated Rock Volume.

Awards & Honors



Young Named Journal Editor

Bureau Associate Director, Environmental Division, Michael

Young has been named editor of the *Vadose Zone Journal*, a leading journal in the area of soil and water resources. His 3-year term began

on January 1, 2013. As the new editor, Michael plans to increase journal visibility through enhanced public relations, further reduce the average time from submission to publication, and promote the journal worldwide. Michael will also

endeavor to build new bridges with the Geological Society of America and the Ecological Society of America, in addition to maintaining the strong foundation that the *Vadose Zone Journal* shares with the American Geophysical Union.



Gale Chosen AAPG Distinguished Lecturer

Julia Gale was selected as an AAPG Distinguished Lecturer for the Fall

of 2013 and Spring of 2014. The program coordinates and sponsors a 2-week period of travel to multiple

geological societies, geoscience departments, universities, and colleges throughout North America. For her Fall 2013 tour, Dr. Gale visited the Upper Midwest, with two talks about natural fractures: one a

summary of work she has done on fractures in shale hydrocarbon plays, the other an exploration of fracture properties across a range of scales. In March 2014 she will be heading to Canada and the western United States.

Staff Receives Multiple Awards at GCAGS 2013

With a large turnout and multiple major-award winners, the Bureau made its presence known at GCAGS 2013 on October 6–8 in New Orleans.



Senior Research Scientist Michael Hudec (left) received the 2012 A. I. Levorsen Memorial Award, which recognizes the

best paper presented, with particular emphasis on creative thinking toward new ideas in exploration. The paper, "Explanation for Differences in

Deepwater Salt Tectonics between the North-Central and Northwestern Gulf of Mexico," also received the



2012 GCAGS/GCSSEPM Thomas A. Philpott Excellence of Presentation Award. Tucker Hentz (left) received the 2013

GCAGS Distinguished Service Award, largely for his editorial contributions to the *GCAGS Transactions* and the newly created *GCAGS Journal* but also for his many publications on



Gulf Coast geology and for his generous volunteer service over the years. Robert Reed (above left) and Stephen Ruppel (below left) placed third in the Gordon I. Atwater Best Poster Award competition for



"Pore Morphology and Distribution in the Cretaceous Eagle Ford Shale, South Texas, USA."



Gülen Selected for 2013 USAEE Senior Fellow Award

Gürcan Gülen of the Bureau's Center for Energy Economics was selected by the 2013 Awards Committee of the U.S. Association for Energy Economics (USAEE) to receive a 2013 USAEE Senior Fellow Award. The award is given to individuals who have

exemplified distinguished service in the field of energy economics and the USAEE. Recognition of his unanimous selection by the committee was conferred at the 32nd USAEE/IAEE North American Conference in Anchorage on July 30, 2013. Founded in 1994,

the USAEE is the largest affiliate of the International Association for Energy Economics, which provides a worldwide forum for the exchange of ideas, experience, and issues relating to energy economics among corporate, academic, scientific, and government professionals.



AGL Researchers Win Geological Society of London Awards

On June 5, The Geological Society (GSL) of London honored winners of its 2013 Award Citations. Receiving honors from GSL President David Shilston were the Bureau's Martin Jackson (left) and Chris Jackson (right). Martin was presented the William Smith Medal celebrating outstanding achievement in the field of applied geology, for which Shilston

noted, "His fundamental research, in partnership with industry via the Applied Geodynamics Laboratory at Austin, which he founded 25 years ago, has revolutionised oil exploration and development in salt-bearing sedimentary basins—fundamentally changing our view of how passive continental margins evolve." Chris received the Bigsby Medal for his application of 3D-seismic reflection techniques to study

geologic processes. Said Shilston, "Chris Jackson is arguably the leading and most productive interpreter of three-dimensional seismic reflection data of his generation, using his skill to understand diverse processes in sedimentary basins. However, he has also applied his skills to such subjects as magma migration, mass wasting, faulting patterns through time, and the complex interplay between erosion and deposition."

Duncan Article Selected for Law Publication



A newly published article by the Bureau's Ian Duncan and UT Law School professor David Adelman has

been selected from a pool of hundreds of law journal articles on

environmental topics for inclusion in the 6th annual *Environmental Law and Policy Annual Review*, a joint publication of the Environmental Law Institute's *Environmental Law Reporter* and Vanderbilt University Law School. The article, entitled

"The Limits of Liability in Promoting Safe Geologic Sequestration of CO₂," challenges several misconceptions about the risks associated with geologic sequestration of CO₂ and the significance of open-ended legal liability.



Scholarships Awarded to Bureau Students

The West Texas Geological Society (WTGS) recently presented \$32,000 in scholarships to 14 students. Among the recipients were 2 students who

have contributed to Bureau research programs. M.S. candidate Logan West (left) has worked with the Gulf Coast Carbon Center (GCCC) under the guidance of Susan Hovorka and Scott Tinker. M.S. candidate

Stefanie Frelinger (right) worked with advisor Peter Eichhubl for the Bureau's Fracture Research and Application Consortium. Both will continue their studies at the Jackson School of Geosciences.

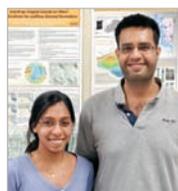


GCCC Staff Present Best Paper at COMSOL Conference

At the COMSOL conference in Boston on October 9–11, Bureau researchers Seunghee Kim

(left), Seyyed A. Hosseini (middle), and Susan D. Hovorka (right) received the Best Paper Award for their paper titled "Numerical Simulation: Field Scale Fluid

Injection to a Porous Layer in Relevance to CO₂ Geological Storage." COMSOL is the premier event for multi-physics modeling and simulation using COMSOL software.



Students Win First Place in SEG Gulf Coast Challenge Bowl

On March 5, Khushboo Arora (left) (GRA with QCL) and Menal Gupta (right) (GRA with EGL) placed first in the SEG Gulf Coast Challenge Bowl in Houston, which is held in conjunction with the Geophysical

Society of Houston Spring Symposium. The SEG Challenge Bowl is an international contest testing students' breadth and depth of knowledge about the geosciences. The quiz-show format features intense competition as the contestants attempt to buzz in

first with answers to challenging geoscience questions. Four other teams competed—one from Rice University, one from The University of Texas at San Antonio, and two from the University of Houston. Arora was the top-scoring competitor.



Dutton Selected as AAPG Distinguished Lecturer

Senior Research Scientist Shirley P. Dutton was invited to participate in the 2013–2014 Distinguished Lecture Program of the American Association of Petroleum Geologists (AAPG). Distinguished Lecturers speak

before geological societies and university geology departments throughout the United States and Canada. Her first lecture tour was in September 2013, and she will tour again in April 2014. The topic of her talk is “Diagenetic Controls

on Reservoir Quality in Deep to Ultradeep Paleogene Wilcox Sandstones, Gulf of Mexico.” This is the second time Dutton has been selected as an AAPG lecturer, having received this recognition previously in 1986–1987.



Romanak Wins Best Presentation Award

Attendees at the 12th Annual Conference on Carbon Capture Utilization & Sequestration (CCUS), convening in Pittsburgh on May 13–16, voted for the presentations they believed to

be the “most groundbreaking, innovative and insightful.” Katherine Romanak was chosen from over 240 speakers for her presentation “Protocol for Response to Claims of CO₂ Leakage: Case Study at

the Kerr Farm, Weyburn-Midale Oilfield.” CCUS will also submit Romanak’s presentation to Wiley’s journal *Greenhouse Gases: Science and Technology* for their consideration for publication.



Loucks Receives KWI Karst Research Award

Senior Research Scientist Robert G. Loucks has been selected by the Board of Directors of the Karst Waters Institute (KWI) to receive the 2014 KWI Karst Award. The KWI, which seeks to further the fundamental

understanding of karst systems through sound scientific research, first presented the award in 1999, to recognize individuals who have had a considerable impact on karst science and research. The Board’s selection recognized Louck’s research in the

relationship between paleokarst and hydrocarbon reservoirs, and in the application of karst processes in reservoir settings. Loucks will present an invited talk at the group’s awards banquet in Houston in March 2014.



Tinker Receives National Awards for Public Service

In late October, Bureau Director Scott Tinker accepted two national awards for his years of extraordinary service to the general public. On October 24, American Institute of Professional Geologists President Ron Wallace presented Tinker with the John T. Galey, Sr., Memorial Public Service Award at the AIPG awards dinner in Broomfield, Colorado. The Galey Award is established to honor geologists who provide “geological expertise where it is

needed by the public at large” and who “have outstanding records of public service on the national, state, or local level well beyond their normal professional responsibilities.” On October 28, American Geosciences Institute (AGI) President and Jackson School of Geosciences Dean Sharon Mosher, on behalf of the AGI, presented Tinker with the group’s Outstanding Contribution to the Public Understanding of the Geosciences award at its Friends of AGI reception

in Denver. The AGI award is bestowed annually on an individual “for contributions leading to greater public appreciation and better understanding of the role of geosciences in society.” Both awards recognized Tinker’s distinguished service as director of the Bureau of Economic Geology and as the State Geologist of Texas, as well as his tremendous outreach efforts through teaching; writing; public appearances; and *SWITCH*, his documentary film about global energy.

Ziolkowska Recognized as Outstanding Young Researcher

In November 2013, the German Academy of Sciences, Berlin, and representatives of the German Senate and German Council for Technology and Innovation, along with other

prominent scientists, selected Jad Ziolkowska as Outstanding Young Researcher for 2013. The ceremony took place on January 22, 2014, in the Berlin Town Hall. The award

is sponsored and granted by the Mayor of Berlin, Klaus Wowereit, and the Senator for Education, Youth and Science, Sandra Scheeres.



Flemings Presents Keynote Address

At the 6th International Symposium on Submarine Mass Movements and Their Consequences in Kiel, Germany, the Bureau's Peter Flemings was a keynote

speaker with his talk titled "Pore Pressure Response to Unloading, Progressive Slope Failure, and the Stratigraphic Record." Flemings also was an invited speaker at the 47th U.S. Rock Mechanics/Geomechanics

Symposium in San Francisco, presenting the opening talk titled "The Science of Pore Pressure Prediction in the Deepwater."



Katherine Romanak, Changbing Yang, and Susan Hovorka (pictured, left to right, with Scott Tinker) received the 2013 BEG Publication of the Year Award for their paper "Process-Based Approach to CO₂ Leakage Detection by Vadose Zone Gas Monitoring at Geologic CO₂ Storage

Bureau Publication Award Winners Honored

Sites", which was published in *Geophysical Research Letters*. The award, given to authors of the year's top peer-reviewed Bureau publication, was presented at the annual Authors Dinner on April 25. More than 40 first authors of 70 peer-reviewed manuscripts were recognized at the event. Runners-up included J.-P. Nicot and Bridget Scanlon for "Water Use for Shale-Gas Production in Texas, U.S.," published in *Environmental Science and Technology*; and Julia Schneider Reece, Peter B. Flemings, Brandon Dugan,

Hui Long, and John T. Germaine, for "Permeability-Porosity Relationships of Shallow Mudstones in the Ursa Basin, Northern Deepwater Gulf of Mexico," published in the *Journal of Geophysical Research*. Almost 60 years



separated the age of the youngest first author from that of the most seasoned veteran, Jerry Lucia (left), who published two peer-reviewed manuscripts last year.



Bureau Staff Receive UT Service Awards

The Bureau paid tribute to its own at the annual UT Staff Service Awards luncheon on May 8. More than 90 researchers, staff, students, visiting scientists, and alumni were

recognized for their contributions during the past year. Program Director Ian Duncan (left, with Scott Tinker) was honored for his 2-year term as BEG Senior Technical Advisor. Receiving service awards (below, left to right) were Eddie Collins, 35 years

service; Tucker Hentz, 30 years service; James Donnelly, Kitty Milliken, and Bridget Scanlon, 25 years; David Boling and Jana Robinson, 20 years; Michael DeAngelo, Ron Russell, and Lesli Wood, 15 years; and Emily Hooks and Xavier Janson, 10 years.



Nicot and Brown Win Jackson School Awards

The Bureau's J.-P. Nicot (left) and Cathy Brown (right) received 2013 Excellence Awards from the Jackson School of Geosciences (JSG). Nicot received the highest award presented by the Jackson School, the Joseph C. Walter

Excellence Award, for excellence in areas including research, teaching service, professional activity, and administration. Nicot served as principal investigator on multiple projects during the past year and garnered special attention for his studies of water-

resource management and water use in shale production. Brown, the Bureau's Media Manager, was presented the JSG Outstanding Service Award, recognizing outstanding leadership and service to the BEG, the Jackson School, the University, and her profession.

Publications

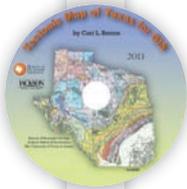
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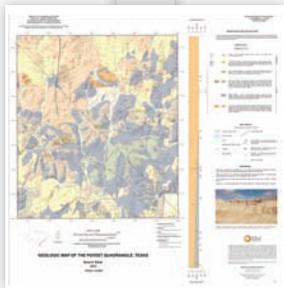
Depositional Systems and Controls on Reservoir Quality (Determined from Core Data) in Deeply Buried Tertiary Strata in the Texas-Louisiana Gulf of Mexico: Ambrose, W. A., Loucks, R. G., and Dutton, S. P., 2013, The University of Texas at Austin, Bureau of Economic Geology Report of Investigations No. 278, 80 p.

In this report, the authors used whole-core data to provide a framework for interpreting depositional origin, reservoir quality, and mineralogical composition in deeply buried (>10,000-ft) Tertiary strata in the Texas-Louisiana Gulf of Mexico.



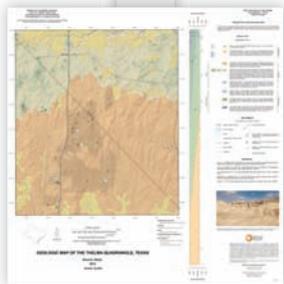
Tectonic Map of Texas for GIS (CD-ROM): Breton, C., 2013, The University of Texas at Austin, Bureau of Economic Geology, GIS001, scale 1:750,000.

A digital version of the map compiled by T. E. Ewing in 1990, this tectonic map summarizes knowledge of surface and subsurface regional structural geology of the State of Texas. Adjoining areas of Mexico, New Mexico, and Oklahoma are included to portray major tectonic elements in their entirety.



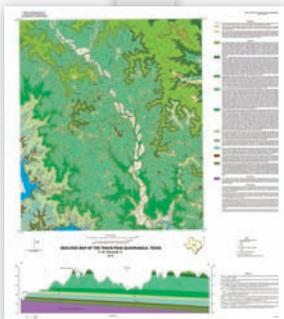
Geologic Map of the Poteet Quadrangle, Texas: Elliott, B. A., 2013, The University of Texas at Austin, Bureau of Economic Geology, Open-File Map, OFM0207, scale 1:24,000.

This map is one of two 1:24,000 geologic maps (Thelma and Poteet quadrangles, Texas) illustrating the geology of Quaternary and Tertiary deposits that overlie Cretaceous strata just south of San Antonio. The Eocene-age Carrizo Sand formation is an important mineral-industry resource in the region, and the geologic maps will assist in recognizing additional economic sand resources.



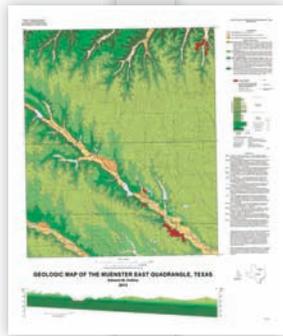
Geologic Map of the Thelma Quadrangle, Texas: Elliott, B. A., 2013, The University of Texas at Austin, Bureau of Economic Geology, Open-File Map, OFM0208, scale 1:24,000.

Another map of Quaternary and Tertiary deposits south of San Antonio. Both of these new maps display existing and inactive quarries for sand resources, which are used primarily for construction material and cement manufacturing in the greater San Antonio region.



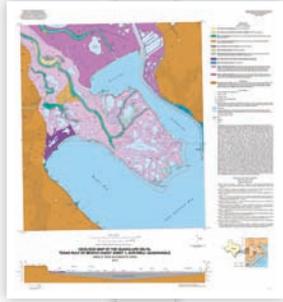
Geologic Map of the Travis Peak Quadrangle, Texas: Woodruff, C. M., Jr., 2013, The University of Texas at Austin, Bureau of Economic Geology, Open-File Map, OFM0210, scale 1:24,000.

The Travis Peak quadrangle comprises dissected terrain on the north side of the Colorado River (impounded in this area as Lake Travis), including Post Oak Ridge, Hickory Gap, Boultinghouse Mountain, the valley of Cow Creek, and the Balcones Canyonlands National Wildlife Refuge (NWR). The area is underlain by an almost complete section of Lower Cretaceous bedrock units and a small exposure of Pennsylvanian Smithwick Shale. In addition to local bulk-rock products (limestone, alluvial sand and gravel, and caliche), key potential ground-water resources are mapped.



Geologic Map of the Muenster East Quadrangle, Texas: Collins, E. W., 2013, The University of Texas at Austin, Bureau of Economic Geology, Open-File Map, OFM0201, scale 1:24,000.

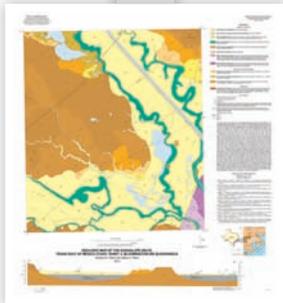
This quadrangle is one of several for the mapping study of the North-Central Texas transportation corridor north of Fort Worth. Maps for this corridor will provide a basic geologic framework to aid in managing water and earth resources, planning land use, identifying aquifer recharge areas, and identifying sources of aggregate and other earth resources.



Geologic Map of the Guadalupe Delta, Texas Gulf of Mexico Coast:

Austwell Quadrangle: Paine, J. G., and Collins, E. W., 2013, The University of Texas at Austin, Bureau of Economic Geology, Open-File Map, OFM0202, scale 1:24,000.

Bureau researchers use high-resolution airborne-lidar data, aerial imagery, ground conductivity measurements, soil analyses, and shallow boreholes and geophysical logs to map surficial Holocene and upper Pleistocene fluvial, deltaic, and estuarine deposits in several quadrangles that encompass the Guadalupe River delta and San Antonio Bay area. This is one of several maps being used to refine the onshore Quaternary stratigraphy.



Geologic Map of the Guadalupe Delta, Texas Gulf of Mexico Coast:

Bloomington Quadrangle: Collins, E. W., and Paine, J. G., 2013, The University of Texas at Austin, Bureau of Economic Geology, Open-File Map, OFM0203, scale 1:24,000.

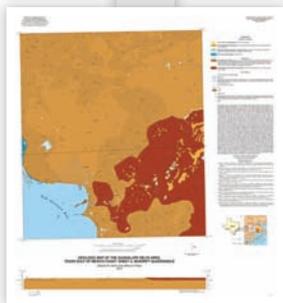
Sheet 2 of the Guadalupe River delta, the Bloomington quadrangle displays the fluvial system of the Guadalupe River, Black Bayou, San Antonio River, and Cushman Bayou where they have dissected into the Pleistocene Beaumont Formation. Point-bar, crevasse-splay, levee, terrace, and floodplain deposits are mapped.



Geologic Map of the Guadalupe Delta, Texas Gulf of Mexico Coast:

Green Lake Quadrangle: Paine, J. G., and Collins, E. W., 2013, The University of Texas at Austin, Bureau of Economic Geology, Open-File Map, OFM0204, scale 1:24,000.

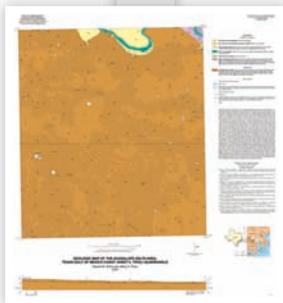
Another 1:24,000 map in the Guadalupe River delta series, this map depicts the Pleistocene and Holocene deposits in the valley and adjacent uplands just upstream from San Antonio Bay.



Geologic Map of the Guadalupe Delta, Texas Gulf of Mexico Coast:

Seadrift Quadrangle: Paine, J. G., and Collins, E. W., 2013, The University of Texas at Austin, Bureau of Economic Geology, Open-File Map, OFM0205, scale 1:24,000.

The Seadrift quadrangle focuses on fluvial, deltaic, and marine-influenced Pleistocene Beaumont Formation deposits adjacent to San Antonio Bay.



Geologic Map of the Guadalupe Delta, Texas Gulf of Mexico Coast:

Tivoli Quadrangle: Collins, E. W., and Paine, J. G., 2013, The University of Texas at Austin, Bureau of Economic Geology, Open-File Map, OFM0206, scale 1:24,000.

Last of the five maps of the Guadalupe River delta, this map presents the geology of the Tivoli area, mostly upland Pleistocene Beaumont clay, silt, sand, and minor gravel of fluvial-deltaic interdistributary and distributary settings. Sand-rich channel facies of the Beaumont Formation are displayed.

Peer-Reviewed Publications by Bureau Researchers

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- Ambrose, W. A., Loucks, R. G., and Dutton, S. P., 2013, Depositional systems and controls on reservoir quality (determined from core data) in deeply buried Tertiary strata in the Texas-Louisiana Gulf of Mexico: *The University of Texas at Austin, Bureau of Economic Geology Report of Investigations No. 278*, 80 p.
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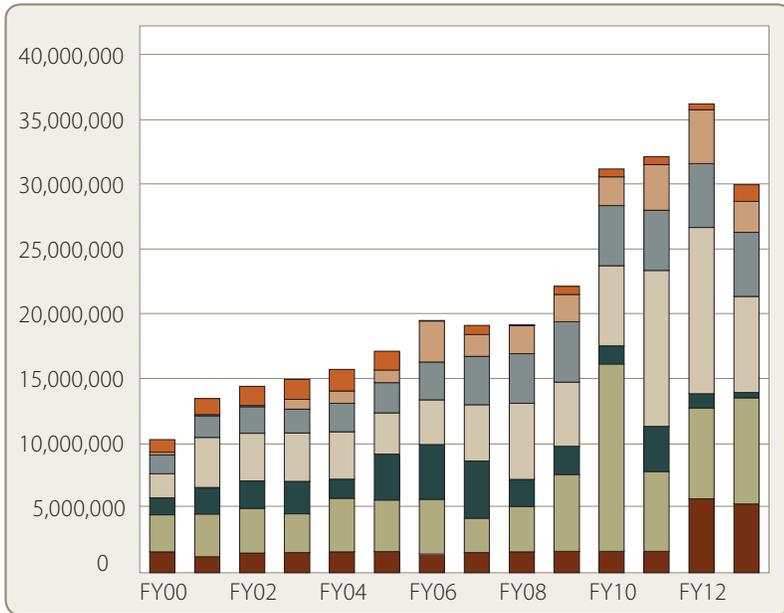
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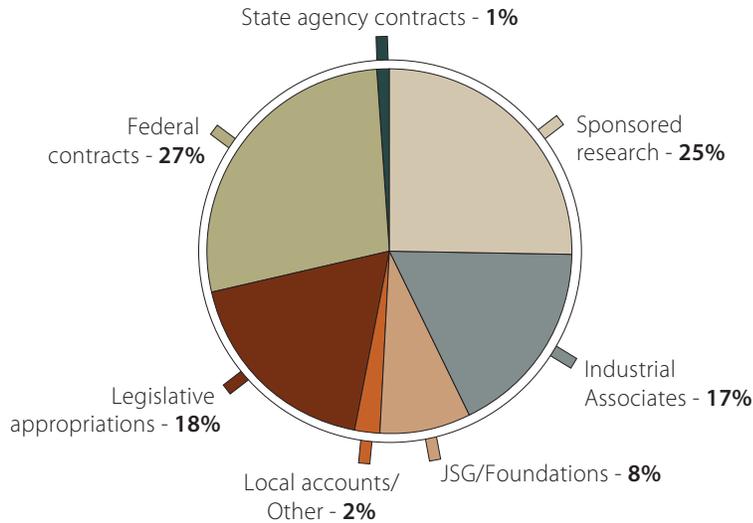


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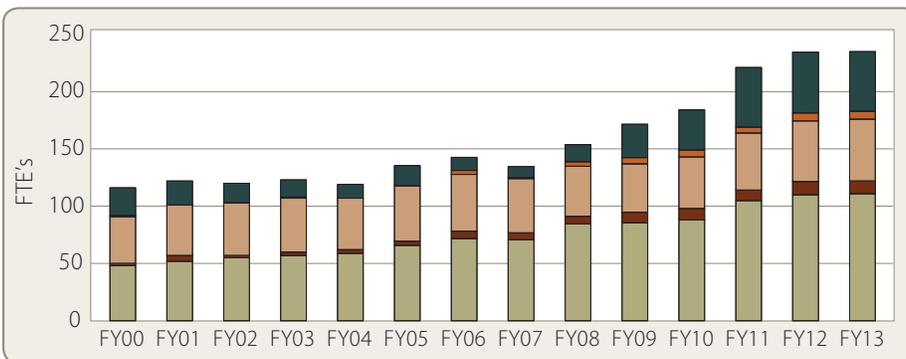


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- Local accounts/Other
- JSG/Foundations
- Industrial Associates
- Sponsored research
- State agency contracts
- Federal contracts
- Legislative appropriations



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In Memoriam

The Bureau mourns the recent loss of Paul Knox, a friend and co-worker. Paul knew at an early age that he wanted to be a geologist, and geology became his vocation as well as his avocation. He earned both his B.S. and M.S. degrees in Geology from California State University at Long Beach, and he later entered the Ph.D. program at The University of Texas at Austin. Paul started work as a roustabout for Union Oil in 1978. After he completed his education, he became a development geologist for Unocal. In 1992 he went to work at The University of Texas at Austin, doing sequence stratigraphy at the Bureau of Economic Geology. He later applied these skills to water, developing the reservoir architecture of several Texas aquifers. Paul was one of the first geologists to be licensed by the Texas Board of Professional Geoscientists.

A memorial tree was planted at the Bureau to remember Paul. Director Scott Tinker said, "I recall Paul for his strength of character, tenacity, love of his dear wife Rosemary, and most of all his infectious smile." Paul was a great joy to know and to be with. He is greatly missed.



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