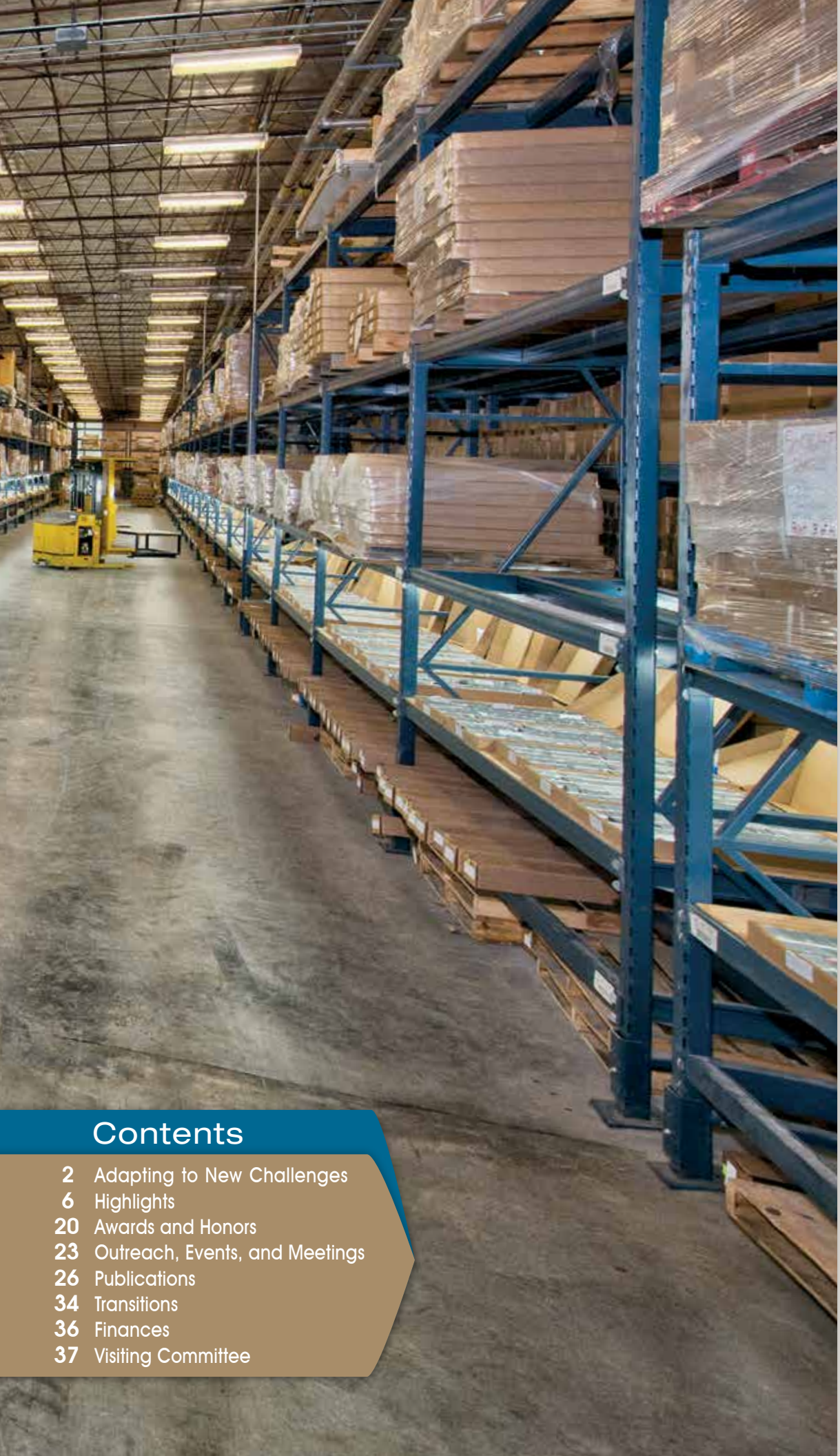

Bureau of Economic Geology
Scott W. Tinker, Director
Annual Report
2014



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Two million boxes filling three giant warehouses across Texas—arguably, the largest collection of archival rock material in the world.

A Letter from the Director

I am wrapping up my 15th year as Director of the 105-year-old Bureau of Economic Geology. The past decade and a half has been both inspiring and fulfilling. I am humbled to be part of such a great organization with deep geologic roots and rich research traditions.

The Bureau has grown substantially in both size and, I believe, quality. Although there are many important components involved in building a successful organization, there is little doubt that talent sits at the top of the stack. In this year's Annual Report, we feature a selection of our talented junior research staff, who are working on a wide array of important fundamental and applied problems, as well as some of our more seasoned vets, many of whom have been doing top-level research for 30, 40, and even 50 years. Three generations under one roof! It is this remarkable range of experience, expertise, and diversity that makes the Bureau so highly valued and respected by the global academic, government, and industrial communities.

As the Bureau continues to bring science, engineering, and economics together to address some of the world's major challenges, we face funding tests of our own. Federal debt continues to grow and Federal investment in research shrinks accordingly. On the industrial side, increased supply and decreased demand for oil in 2014 drove the price from over $100 a barrel to below $60 a barrel in a matter of months, causing significant belt tightening in the private sector and attendant reductions in research investment.

The Bureau will weather these gales. As we focus on several new, long-term research partnerships that bring government, science-funding foundations, industry, and academia together to address several critical issues, we know that the years ahead hold many exciting opportunities.

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The Next Generation of Bureau Researchers

For over 100 years, the Bureau of Economic Geology has sustained an international reputation for producing rock-based research that matters. Underpinning that reputation have been generations of geoscience researchers who have applied their expertise and innovative ideas to the earth-science questions of their day. As the Bureau embarks on its second century, a new generation of researchers has stepped up to address a different era of technological and theoretical challenges that spring from the confluence of energy, the environment, and the economy.

Todd Caldwell generates data for the Texas Soil Observation Network (TxSON).

The novel investigations of these up-and-coming researchers enhance the Bureau's reputation, allowing it to stay ahead of the curve of a rapidly changing research environment.

In the late 1970's and early 1980's, the oil and gas industry was strong, attracting a large number of young people into the field to study geology, petroleum engineering, energy finance, and related subjects. Scores of graduates in these and similar disciplines readily found work in the industry. But the crude-oil price crash of the mid-1980's brought exploration efforts to a halt and forced oil and gas companies to pull back. Hiring virtually ceased, and the academic programs that had produced so many industry employees were either curtailed or discontinued altogether. A chasm began to open in the oil and gas workforce, with experienced professionals growing closer to retirement as the years passed and few trained individuals moving into the pipeline to replace them. Energy and environmental organizations of all types, from the oil company majors to academic institutions, have been scrambling for the last decade to close that workforce gap and to bring talented younger professionals into these fields.

The Bureau of Economic Geology has been fortunate in its endeavor to close this troubling gap, with its deep base of experienced mentors and a cadre of gifted new researchers, all bringing impressive backgrounds with them as they spearhead new scientific thrusts in energy and environmental labs. Space precludes listing all of the laboratories and research efforts that are predominantly led and staffed by this new generation of Bureau researchers, but a few are highlighted here.

Drought has been a major concern across different regions of the United States for several years, and the Bureau has been extensively studying both its cause and how to measure its effects. As part of that effort, the **Soil Characterization Laboratory**, led by **Todd Caldwell**, is the headquarters for the Texas Soil Observation Network (TxSON). TxSON places soil-monitoring stations across the State to measure how dry its soils have become and uses that data to calibrate a new NASA satellite launched in early 2015. With the ongoing drought in Texas, most rainfall is being absorbed by dry soil and is not running

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off into streams and reservoirs, or recharging aquifers, so TxSON data will be increasingly important to the State's water-management decision makers going forward.

Rocks are the foundation for most Bureau research, and a great number of up-and-coming researchers devote considerable effort to harvesting data from the organization's **Core Research Centers**. This next generation of Bureau researchers includes people like **Athma Bhandari, Gregory Frébourg, Iulia Olariu, Harry Rowe, Xavier Janson, Peter Flaig,** and **Chris Zahm,** who perform fundamental rock-based research on subsurface cores. The scope of research activities in this area includes everything from low-magnification visual description, to X-ray fluorescence and X-ray diffraction analysis to determine mineralogy and trace-element chemistry, to fracture description and rock-strength measurements. These activities are critical for defining depositional environments and facies, as well as mechanical stratigraphy, all of which form the basis for developing models of rock property distribution. This research also provides basic information for calibrating and interpreting borehole and 3D geophysical data. Allied activities include rock sampling for thin sections (to refine depositional environments), stable isotope chemistry (to aid in correlations and interpreting diagenesis), scanning electron microscopy (to define pore types and distribution and products of diagenesis), and other procedures such as porosity/permeability analysis. The more knowledge gleaned from the rocks, the more

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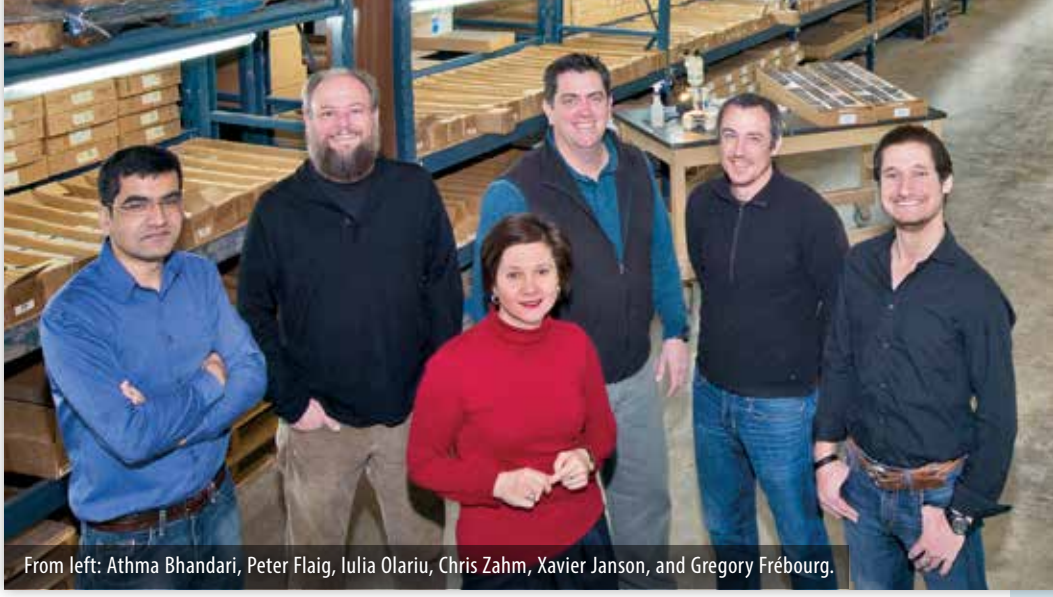

From left: Athma Bhandari, Peter Flaig, Iulia Olariu, Chris Zahm, Xavier Janson, and Gregory Frébourg.

Seasoned Scientists

The Backbone of the Bureau of Economic Geology

The Bureau of Economic Geology is proud of its younger researchers, but the real backbone of the organization is its corps of seasoned scientists—the foundational researchers and project leaders to whom credit must be given for the Bureau's unparalleled reputation for scientific innovation and objectivity. Many of these distinguished individuals have been with the Bureau for decades, providing a wide range of current research initiatives, and conveying their breadth of experience and stores of knowledge to scores of emerging scientists and students.

These veterans of service to the Bureau of Economic Geology have weathered the organization's growth and evolution, always dedicated to its mission, and have tirelessly focused on producing research that matters. The Bureau's seasoned scientists have created a lasting legacy of achievement and success.

Veteran Bureau Scientists

Top row:
Martin P.A. Jackson,
Michael H. Young,
Bob A. Hardage,
Bridget R. Scanlon,
Sergey B. Fomel,
Susan D. Hovorka,
Stephen C. Ruppel,
Robert G. Loucks

Bottom row:
Shirley P. Dutton,
Lesli J. Wood,
Jeffrey G. Paine,
Peter B. Flemings,
Michael R. Hudec

successful geoscientists the world over will be in interpreting the characteristics of specific rock formations and fluid reservoirs.

The **Low Temperature Geochemistry Laboratory** provides equipment and facilities to physically re-create geochemical processes and confirm theoretical models crafted from field observations. Modeling analytical data and integrating field observations help researchers to formulate theories on Earth's processes that have occurred in the geologic record and on how rocks, minerals, fluids, and gases form the way they do. The work conducted in this lab helps geoscientists to identify the geochemical and isotopic fingerprints for oil and gas, and to better understand the processes for mineral development, thereby paving the way to make future drilling and mining operations more efficient and successful. Among the next-generation researchers extensively using this lab for their respective research interests are **Brent Elliott, Seyyed Hosseini,** and **Jiemin Lu**.

Jiemin Lu and Brent Elliott transfer a water sample taken from a high T/P autoclave reactor.

The Bureau's **Organic Geochemistry Laboratory** has been developed to study hydrocarbon chemistry and source-rock properties. The lab's capabilities include identification and quantification of 18 gas components; oil extraction from organic-rich shales; liquid hydrocarbon identification and quantification;

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Post-Docs and Graduate Students a Vital Resource

Over the last 10 or so years, the Bureau has tapped into a tremendously important resource that previously was not used extensively: post-doctoral fellows and graduate students. This young and energetic group of researchers has added much-needed horsepower to our existing permanent staff. In the mid-2000's, the Bureau employed only 2–3 post-docs and 20 grad students. These numbers have increased substantially since then. Though the number of post-docs constantly varies, as of September 2014, the Bureau was hosting approximately 15 dedicated post-docs in all areas of research, from carbon sequestration to salt tectonics to geomechanics of fracture systems. This fiscal year, the Bureau employed and advised 54 graduate students, a solid increase in capacity and diversity.

These folks have strengthened the Bureau in a number of ways. First, post-docs and grad students are strongly encouraged to publish peer-reviewed articles. From 2005 to 2013, the annual number of peer-reviewed articles increased from 76 to 124. In 2005, 32 of those articles were lead-authored by post-docs or grad students; by 2013, that number had increased to 47. Second, these young researchers are, in many ways, key components of Bureau research programs, conducting experiments in the laboratory and field as they learn the ropes of high-level geosciences research. Third, the post-doc fellows represent a source of potential permanent hires—a vital bonus as the demographics of the geosciences workforce is affected by retirements.

We are proud of our participation in the training of these young scientists, and we benefit in many ways from their time at the Bureau.

Sergey Fomel and his MS student Shaunak Ghosh.

Bureau Rock Archive Key to Research

Two million boxes filling three giant warehouses across Texas—arguably, the largest collection of archival rock material in the world. That describes the Bureau's library of well core, cuttings, and other rock materials now housed and maintained as a public resource in its Houston, Austin, and Midland Core Research Centers. Geoscientists, engineers, researchers, educators, students, and the general public travel from around the world to unlock the stories held in these irreplaceable rocks that answer questions and generate new ideas about precious subterranean commodities like oil, water, and natural gas. Although the expensive process of coring a well is not as common these days, there is still no better way to determine rock characteristics firsthand.

But how did the collection become so massive? Largely through donations of rock material over the years from companies large and small. When a company has learned what it can from the rocks it has retrieved from thousands of feet below its leases, there is no better option for their disposition than to donate them to the Bureau. The Bureau continually fields calls and e-mails from geologists and other industry representatives hopeful of turning over their cache of core, cuttings, and other rock samples to an organization with the facilities and people best positioned to care for them. One advantage to donating the rocks is the continued ability to revisit them, answering any new questions that may arise. Bureau staff are careful curators of these vital rock samples, preserving them just as if they were great books from an ancient library.

Donating is also good for the bottom line: companies avoid costly storage and disposal fees. Companies donating rock material also make tax-deductible financial contributions to the Bureau's core research endowment, the proceeds from which help to pay for operations to care for the core, cuttings, and other rocks over time. Among the major donors to this endowment are Chevron, BP, ConocoPhillips, Marathon, Shell, and Occidental Petroleum.

Ultimately, the Bureau's mammoth archive of rock material is the foundation for its cutting-edge energy and environmental research. For more information about donating rock material to the Bureau Core Research Centers, contact **Mark W. Blount**, External Affairs at the Bureau: 512-471-1509; mark.blount@beg.utexas.edu.

and analysis of source rocks, including surface area, pore volume, and pore-size distribution. The lab's sophisticated instruments allow detailed characterization of gas and liquid hydrocarbons and of source-rock pores, information vital to today's shale exploration and production activity. Among the up-and-coming researchers who perform meticulous analyses in this lab are **Tongwei Zhang, Xun Sun,** and **Daniel Enriquez**.

The Bureau continually strives to find and recruit gifted young professionals to explore the various realms of energy, environmental, and economics research. The Bureau is a dynamic institution whose research is driven not only by the times but also by the imagination of its researchers. The new concepts brought to the table by the next generation of researchers will help shape the institution's direction for years to come and allow it to adapt to, and impact, the challenges of the future. ■

Tongwei Zhang, Daniel Enriquez, and Xun Sun operate instruments that allow detailed characterization of gas and liquid hydrocarbons and of source-rock pores.

Campaign for Texas

The Bureau of Economic Geology would like to thank the many donors who contributed to our success during The University of Texas at Austin's $3.12 billion Campaign for Texas, which concluded in 2014. The support of our donors was, and remains, vital to enhancing the research mission of the Bureau, and we are extremely grateful. Some of the major donors to the Bureau during the Campaign for Texas are listed below.

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A Classroom at the Edge of the World

"A Classroom at the Edge of the World" tracks the journey of a group of 58 graduate students and 17 professors to study geology and petroleum engineering in Svalbard, Norway, which lies in the frigid reaches of the Arctic. The Svalex (for "Svalbard expedition") field trip, hosted by research partner Statoil aboard the vessel *Expedition*, is detailed in *Alcalde*, a publication of The University of Texas Ex-Students' Association. To read the full story: http://alcalde.texasexes.org/arctic/.

Spanish-Language Webinars

Vanessa Nuñez-Lopez of the Bureau's Gulf Coast Carbon Center is helping to overcome language barriers in technology transfer with a series of Spanish-language webinars exploring enhanced oil recovery (EOR) and carbon capture and storage (CCS). As part of the Global CCS Institute's capacity development with Mexico, Nuñez-Lopez created and delivered three CCS-focused webinars to the Comisión Federal de Electricidad (Mexico's Federal Electricity Commission), the Academic Council of Earth Science Schools, and La Secretaría de Energía (Mexico's Ministry of Energy). Nuñez-Lopez also delivered another webinar hosted by the Institute, covering "The Global Status of CCS" and outlining the challenges of utilizing CO_2 for the development of extra-heavy oils, such as those in the massive Orinoco Belt. This webinar was the first in a three-part series that the Institute will hold in Spanish for Venezuelan stakeholders who are exploring ways to limit the impact of the country's carbon-intensive activities on climate change. The next webinar will focus on immiscible CO_2-EOR and associated issues. For more CCS information: http://www.globalccsinstitute.com.

Facilities Renovation Campaign

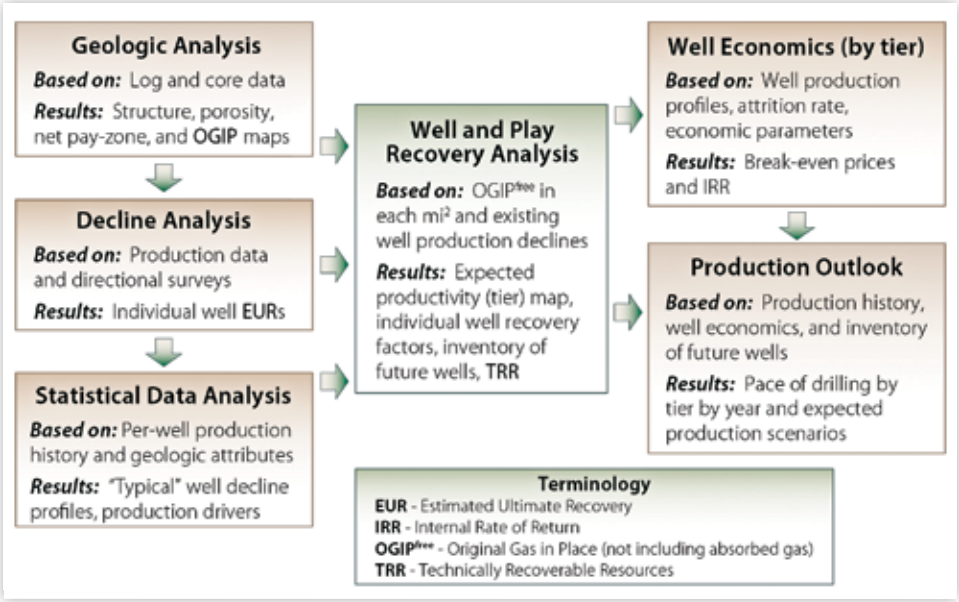
In 2014, the Bureau began a major effort to raise funds to bring its labs and research facilities to a state-of-the-art level. This effort is a top priority for the Jackson School. There are funding opportunities to underwrite a core examination building to be used exclusively by Bureau researchers, or to support upgrades to research complexes and individual labs. For more information, contact **Mark W. Blount**: 512-471-1509; mark.blount@beg.utexas.edu.

As this report went to press, it was learned that UT President Bill Powers had committed The University to invest $7.5 million in support of the ongoing lab renovation campaign in early 2015. The Bureau is very grateful for this vote of confidence in its research capabilities and will continue to seek external funding for the overall effort.

Bureau Awarded Grant for Shale Oil Study

Principal Investigators: **Scott W. Tinker**, Svetlana Ikonnikova, and John Browning

With U.S. oil production from shale formations making international headlines, a team of researchers from the Bureau has just been awarded over $1.5 million to study the nation's two most prolific shale oil plays and their impact on future energy supply. The Alfred P. Sloan Foundation recently confirmed the award of the grant, coming on the heels of the completion of the team's groundbreaking study of four immense U.S. shale gas plays: the Barnett, Fayetteville, Haynesville, and Marcellus.



Workflow in shale plays analysis.

The shale oil study will be the most comprehensive look at actual well-by-well results from the Bakken and Eagle Ford shale oil plays to date. The 2-year study will include geologic description, resource estimation, and future-production modeling, leading to greater understanding of expected oil recovery from each existing well. The study will then extrapolate the results to predict the potential recovery from all potential well locations in each basin, giving a "bottom-up" view of projected production and reserves. Ultimately, the study will help to determine the capability of U.S. shale oil to contribute significantly to oil supply for the next 20 years, under various economic and technological assumptions.

SWITCH Project Offers Resources for Educators

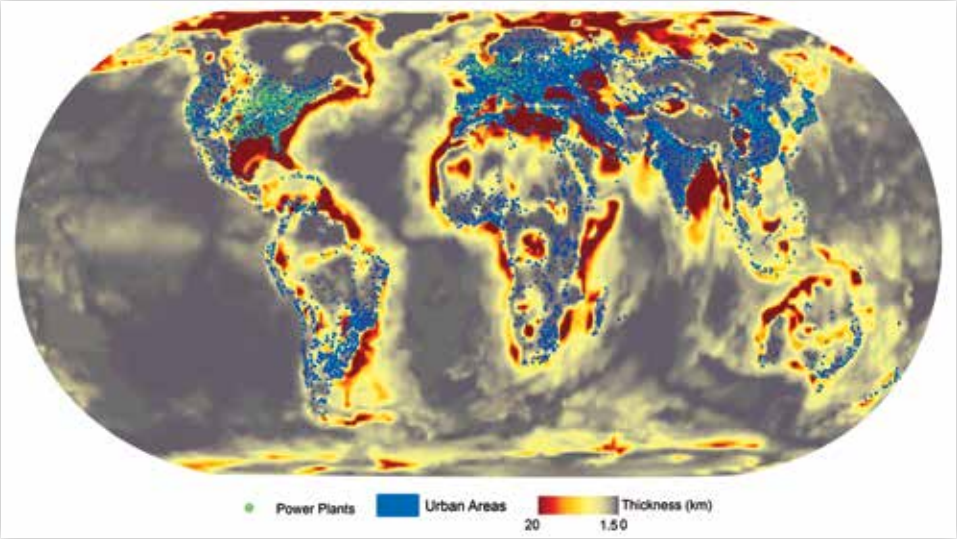
In 2014, the *Switch* Energy Project, led by Bureau director **Scott W. Tinker** and filmmaker Harry Lynch, developed a number of resources to help educators promote energy education, awareness, and efficiency. Tinker, Lynch, and the *Switch* Energy Project team wrapped production on the *Switch* Energy Lab series of educational videos, which are intended to be used in classrooms along with existing curricula or in other educational environments such as museums. In these brief videos, Tinker uses unique experiments and fieldwork to demystify the complex world of energy and get to the core of energy concepts. In conjunction with the National Energy Education Development (NEED) Project, the *Switch* Energy Project is developing curricula that will incorporate the Energy Lab videos into NEED's existing materials.

Tinker and Lynch previously collaborated on *Switch*, the award-winning documentary about the future of global energy that has been seen by over 8 million viewers. The *Switch* Energy Project has provided free DVD's of *Switch*, in chapter format, to nearly 30,000 teachers worldwide. The Project's website offers free online downloads of the film and its specific segments to educators; the website surpassed 1 million page views in 2014 and has hosted over 185,000 unique visitors. For more information, visit: http://www.switchenergyproject.com/education/energy-lab.

Gulf Coast Carbon Center

Principal Investigators: Susan D. Hovorka and Timothy A. Meckel

The Gulf Coast Carbon Center (GCCC) continues to be a leader in the development of strategies that improve the robustness of geological carbon storage (GCS) and monitoring technologies. In 2014, the work of the GCCC was defined by six broad themes.



Globally, sources of CO_2 (in green) align with offshore geologic storage capacity.

- "How much, how far, how fast" is a research theme focusing on understanding the dominant subsurface flow processes. The key challenges for GCS are significant: in buoyancy-dominated flow, CO_2 may travel much farther than anticipated (how far) by conventional modeling/simulation, thereby greatly decreasing volumetric storage efficiency (how much) and possibly impacting security (how fast).

- GCCC investigates the evolution of fluid chemistry from the deep reservoir to the near surface as it pertains to geological carbon sequestration. Field tests such as those at the Cranfield site in Mississippi, the Hastings and West Ranch sites near Houston, and UT's Brackenridge Field Laboratory in Austin all aid in the characterization of dissolution, dilution, adsorption, and mineral-fluid interaction. Integration with laboratory analysis and numerical simulation extend results and interpretation.

- Another research theme studies the technical changes that would be imposed on current CO_2 enhanced oil recovery (EOR) operations by large volumes of CO_2 stored during commercial implementation of carbon capture utilization and storage (CCUS). The research for this theme clarifies the role of EOR as part of CCUS and improves understanding of greenhouse-gas accounting when EOR is part of the system.

- Many monitoring techniques for assurance of carbon storage have been demonstrated, and a commercial monitoring program will likely involve the use of a number of these techniques. One GCCC research theme focuses on streamlining the design of industrial-scale monitoring programs by field demonstration of monitoring tools and development of monitoring-network optimization strategies under a risk-informed paradigm.

- The best geologic storage options in many parts of the world may be in subsea sedimentary basins; however, only small parts of this potential have been sufficiently assessed to engage stakeholders. Another GCCC research theme incorporates recent in-house data collection and research with findings from global offshore storage projects to identify areas around the world where the best synergies exist both for early GCS experiments and for large-scale deployment in an offshore setting.

- Knowledge transfer has long been a goal of the Gulf Coast Carbon Center, and the group continues to leverage its established, high-profile programs to engage key stakeholders, including decision makers and relevant industry and regulatory participants, and to provide formal and informal education.

GCCC Policy Briefings

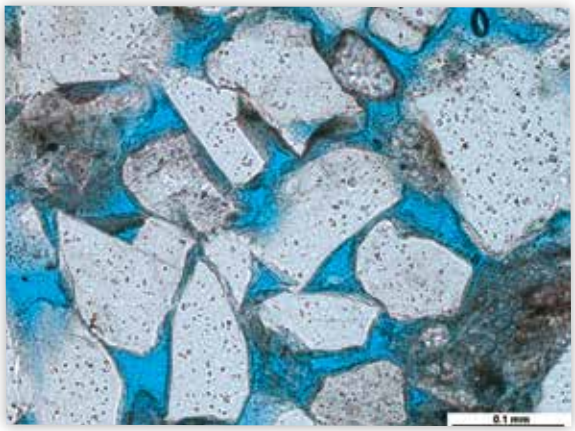
In December 2014, Gulf Coast Carbon Center (GCCC) researchers **Katherine Romanak** and **Vanessa Nuñez-Lopez** attended the COP20 climate conference in Lima, Peru, where they were invited to attend a briefing by Mike Boots for a small group of university representatives. Boots heads the White House Council on Environmental Quality (CEQ), which helps to develop the Administration's environmental and energy policies and initiatives, and works closely with Federal agencies to implement them.

Earlier in the year, Romanak traveled to Washington, D.C., to present "Monitoring and Environmental Protection at Geologic Carbon Storage Sites" for the U.S. Congressional Briefing Series "Energy from the Earth." The series was designed by a consortium of professional geoscience societies to inform energy legislation by making technical information available to U.S. policy-makers. Romanak gave her briefing during Part 6 of the series, "Geologic Carbon Storage: Feasibility, Technology, and Challenges," and addressed issues such as geological requirements for carbon dioxide storage; potential for storage in the United States; facility design and technology; strategies to minimize risk, including groundwater impacts and the potential for induced seismicity; and monitoring needs for storage verification and public assurance.

Katherine Romanak and Vanessa Nuñez-Lopez in Lima with CEQ head Mike Boots.

Reservoir Quality in Deep Shelf Gas Plays

Principal Investigators: Shirley P. Dutton and Robert G. Loucks



The Bureau has an ongoing research project to study reservoir quality in the deep shelf gas play and adjacent deepwater Gulf of Mexico (GOM). The major research goal of this project is to decrease the exploration risk in deep to ultradeep drilling by providing concepts and empirical data that can be used to forecast reservoir quality and associated risk factors. Previous phases of the project summarized Tertiary reservoirs of the northern Texas Gulf Coast, the southern Texas Gulf Coast, and the Louisiana coast, as well as the Upper Cretaceous Tuscaloosa and Woodbine sandstones in onshore Louisiana and Texas, the adjacent shallow shelf, and the deepwater GOM.

Deep shelf and deepwater research this year expanded the study of deep lower Tertiary reservoirs after new data from far south Texas became available. Investigation in 2014 focused on the reservoir quality and sequence-stratigraphic framework of lower Tertiary Wilcox sandstones in the western GOM, using cores from Fandango Field, Zapata County, in far south Texas. These upper Wilcox sandstones provide additional information about the composition and diagenesis of Wilcox reservoirs in the western GOM and are particularly applicable to understanding Wilcox sandstones in the deepwater Perdido fold belt area along the boundary between U.S. and Mexican waters.

In 2015, the stratigraphic coverage of the study will expand to include Upper Jurassic sandstones of the Cotton Valley Group and Smackover Formation, focusing on the northeastern GOM.

Sustainable Water Resources Program

Principal Investigators: Bridget R. Scanlon and Jean-Philippe Nicot

In 2014, the Sustainable Water Resources (SWR) Program compared hydraulic fracturing (HF) water use for oil versus gas production within the Eagle Ford Shale. The group found similar average water use in oil and gas zones per well; however, about twice as much water is used per unit of energy in the oil zone as in the gas zone. These unconventional water-to-oil ratios (0.2–1.4) are within the lower range of those for U.S. conventional oil production (0.1–5), indicating that the United States is using more water because HF has expanded oil production, not because HF is using more water per unit of oil production.

The SWR group evaluated vulnerability of HF by comparing HF water demand with supply in the semiarid Texas Eagle Ford play, the largest global shale-oil producer. Current HF water demand equates to ~16% of total water consumption in the play area. The variety of water sources in semiarid regions indicates that, with appropriate management, water availability should not physically limit future shale energy production.

The SWR group uses GRACE satellites to assess trends in water storage in global river basins and aquifers, including the Murray–Darling Basin and the High Plains, Central Valley, and NW India aquifer systems. The group compiled extensive data from global models and monitoring data for comparison with estimates of water-storage changes in these basins, as well as data on remote sensing and modeling networks to provide hydrologic information in data-constrained regions.

The SWR group is also investigating shallow aquifers across several Texas shale plays—including Barnett, Eagle Ford, Haynesville, and the Delaware Basin—to understand the source, origin, and flux of methane, which appear to be mostly natural. In addition to the extensive field-sampling effort to understand the transport and geochemistry of methane in the subsurface, the group is also investigating methane attenuation and the assimilative capacity of the aquifers.

Roxana Darvari performs rock-water interaction experiments in autoclave reactors.

Working with industry partners, the SWR group also performs rock-water interaction experiments in autoclave reactors at reservoir conditions, under high temperatures and pressures. Core fragments are exposed to various HF fluids, and chemical evolution of the fluid and petrographic changes through time are noted, providing a fine understanding of the nature of the flowback and produced water.

The SWR group, in collaboration with the Center for Agriculture Resources of the China Academy of Sciences, has evaluated the impact of irrigated agriculture on groundwater sustainability and nitrate loading of the aquifers of the North China Plain and the U.S. High Plains. Both aquifer systems are critical for food production, located in similar semiarid climate zones, and vulnerable to climate extremes. This investigation followed on a foundation of extensive research and publication on the Ogallala Aquifer of the High Plains, establishing the Bureau as the leader in water resources of the region.

Center for Energy Economics

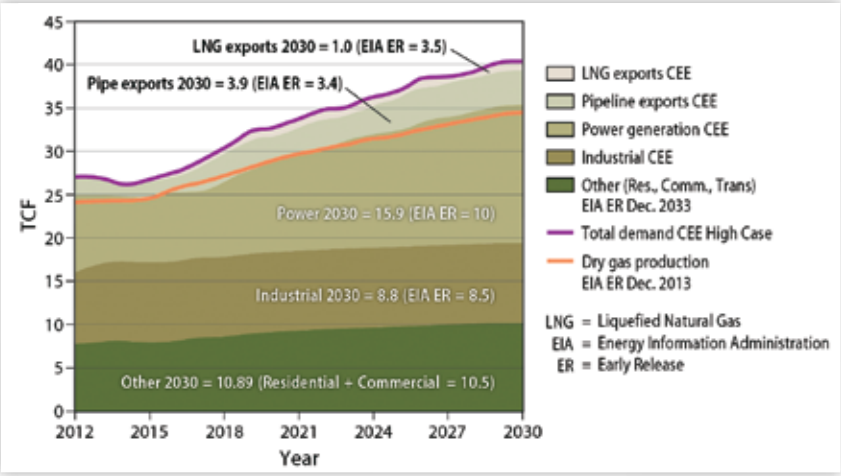
Principal Investigators: Michelle M. Foss and Gürcan Gülen

The Center for Energy Economics (CEE) developed and continues to update an industrial projects database that tracks increasing demand for natural gas in gas-intensive sectors. Preliminary results of this comprehensive inventory of 144 projects received widespread coverage in numerous media outlets, and presentations on CEE results have been delivered to a wide range of audiences, including the Gulf Coast Power Association, URTeC, and the International Energy Credit Association in the United States; the annual Flame gas conference in Amsterdam, the Netherlands; and the Emirates Center for Strategic Studies and Research 20th Annual Energy Conference in Abu Dhabi, UAE. CEE research on industrial gas demand also has been featured in numerous corporate board and advisory presentations.

In 2014, the CEE initiated investigations of global petrochemical value chains, especially the ethylene chain, to evaluate the competitiveness of U.S. petrochemical facilities in a world of increasing capacity in the Middle East and Asia, and to evaluate fluctuating oil and gas prices. CEE research efforts include supporting midstream infrastructure and associated developments.

CEE research was also the basis for expert testimony on potential natural-gas utilization and electric-power-sector modeling results to the Public Utility Commission of Texas workshop on the EPA's proposed clean power rule and implications for Texas. The CEE is also tracking the impact of EPA regulations on coal power-plant retirements and the potential for increased gas use in power generation. Using AURORAxmp®, the group models electricity markets to evaluate the impacts of coal retirements, renewables integration, and capacity markets for the Electric Reliability Council of Texas (ERCOT) and the United States.

CEE researchers continue to work on the Bureau's shale resource-assessment study, contributing to economic and statistical analyses. A goal for 2015 is to produce an expanded summary report that blends shale-gas resource-assessment findings with CEE analysis and modeling on gas utilization.



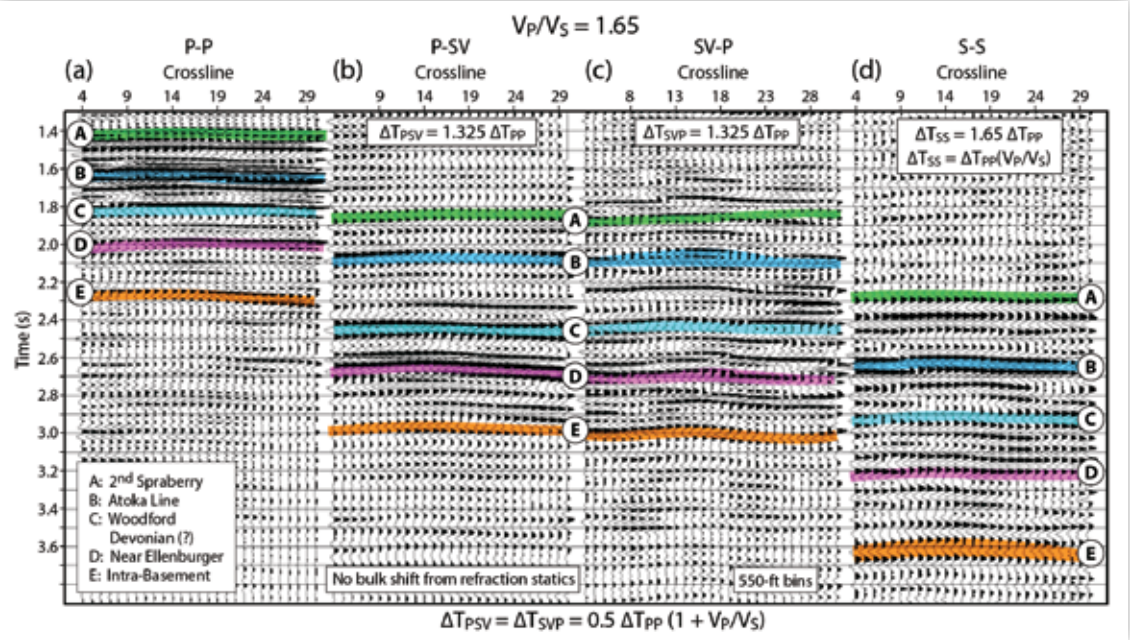
Exploration Geophysics Laboratory

Principal Investigator: Bob A. Hardage

The Exploration Geophysics Laboratory (EGL) develops multicomponent seismic technology and performs field tests that demonstrate practical uses of that technology. The EGL's present focus is the development of direct-S reflection seismology that utilizes only vertical-displacement seismic sources such as vertical vibrators, vertical impacts, and shot-hole explosives. These sources are commonly viewed as only P-wave sources. A "direct-S" mode is an S-wave produced directly at a source station rather than the common P-to-SV converted mode created at interfaces remote from a source station. EGL research is producing evidence that direct-S modes produced by P-wave sources are equivalent to direct-S modes produced by horizontal-displacement sources such as horizontal vibrators. These latter sources are considered to be the gold standard for direct-S illumination of geology.

Once accepted that a P-wave source generates a robust direct-SV mode, a fascinating possibility arises—that SV-P converted modes can be used to make S-mode images and to obtain S-wave attributes across geologic targets. The appeal of SV-P modes is that they exist in common P-wave seismic data. Downgoing illuminating SV-wave fields are produced by vertical-displacement sources (P-wave sources), and reflected upgoing P-wave fields are recorded by single-component vertical geophones (P-wave receivers).

(continued on page 13)



Four seismic images extracted from wave fields produced by a vertical-vibrator source. Two images (P-P and P-SV) are produced by the direct-P mode, and two images (SV-P and S-S) are produced by the direct-SV mode. A, B, C, and D are depth-equivalent horizons in the four image spaces. Data collected in the Midland Basin.

Thus it is conceivable that with EGL technology, decades of legacy P-wave seismic data can be reprocessed to extract direct-S information and S-wave attributes.

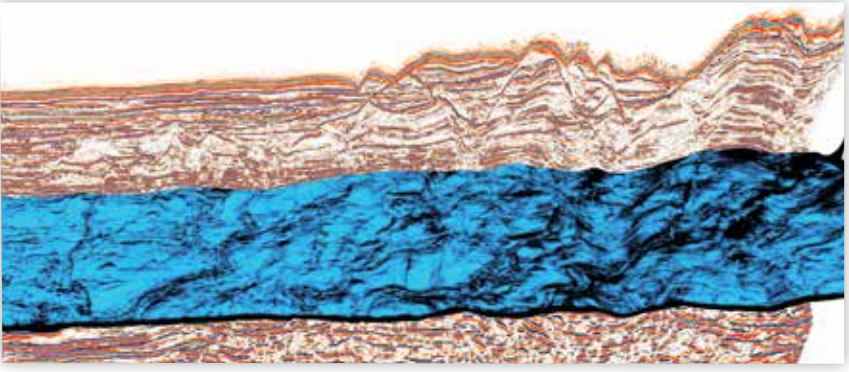
Four patents have been issued to the Board of Regents of the University of Texas System to protect EGL's direct-S technology for University benefit. A company called VertiShear has been established to assist the University in commercializing this technology.

Reservoir Characterization Research Laboratory

Principal Investigators: Robert G. Loucks and Charles Kerans

The Reservoir Characterization Research Laboratory (RCRL) for carbonate studies is a worldwide leader in carbonate research and has been an active partner with industry for the past 27 years. During 2014, 33 member companies participated in the group's annual meeting to review research milestones. The RCRL also conducted several field trips, core workshops, and site visits to company offices.

The group continues to emphasize the integration of outcrop and subsurface data that can be applied to exploration and production in carbonate strata worldwide. In 2014, the RCRL conducted outcrop analog studies of various shallow-water strandplain and shelf strata, as well as of drowned-shelf "unconventional" settings. The role of oceanic anoxic events in influencing long-term trends in platform evolution has also been an ongoing focus of the group's research.



In 2014, the RCRL—using photogrammetry and unmanned aerial vehicles—captured and characterized 3D outcrop models in the Permian of West Texas, in numerous Cretaceous outcrop localities in Central Texas, and in large-scale facies and fracture patterns of West Caicos. The group also increased its capability of rock-properties characterization by adding a range of rock mechanics tests that use the new Bureau triaxial equipment in workflow. Successful calibration of the Equotip Bambino to rock mechanics analysis allows for the characterization of high-resolution rock-strength profiles in carbonates, which the RCRL has demonstrated in the Niobrara Chalks and the Scurry Area Canyon Reef Operators Committee (SACROC) unit.

Near Surface Observatory

Principal Investigator:
Jeffrey G. Paine

The Near Surface Observatory (NSO) is an aggregation of several Bureau research groups and individuals who conduct studies focused on the surface and near-surface environment. Augmenting the efforts of staff is a suite of airborne, surface, and borehole instruments that provide information on the physical properties of the near surface and allow NSO researchers to conduct (1) geologic mapping in diverse environments, and (2) studies on coastal hazards and geomorphic change, wetlands status and trends, coastal rookeries vulnerability, landscape characterization and evolution, periglacial landforms, soils, water bodies, and soil-moisture monitoring.

On the coast, highlights include

- completing a study assessing historical Texas shoreline change and its postglacial context;
- evaluating the nearshore bathymetric and coastal geomorphic change-monitoring capabilities of the Chiroptera airborne lidar instrument adjacent to South Padre Island and Rollover Bay;
- assessing the vulnerability of upper Texas coast rookery islands to oil spills;
- acquiring airborne lidar data in the Copano and Aransas Bay system to assess land loss and coastal vulnerability; and
- completing the 17th year of the Bureau's highly successful outreach effort, the Texas High School Coastal Monitoring Program.

Airborne lidar image of Hoover Dam, Nevada.

In addition, the NSO completed two quadrangle-scale geologic maps of Quaternary strata in the Copano Bay area as part of the Bureau's larger geologic mapping effort described more fully on page 18.

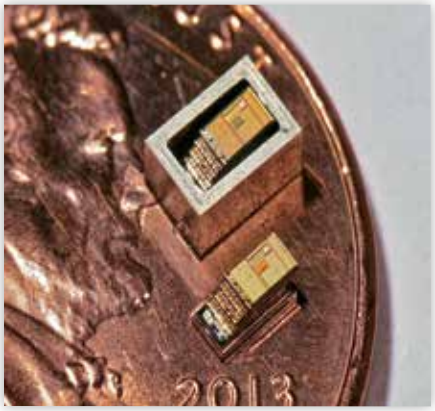
The NSO used data from its lidar team's late-2013 airborne lidar survey of the Wink, Texas, area to determine decadal subsidence rates near two large sinkholes that collapsed in 1980 and 2002, and to assess collapse risk in adjacent areas. The NSO is also analyzing its 2013 airborne lidar survey in Nevada to determine vegetation characteristics that enable development of a fine-scale model to understand and predict the occurrence of the desert tortoise in the Boulder City Conservation Easement and similar landscapes. Primary objectives are to determine vegetative cover, percent shade cover, and species richness of perennial and ephemeral species. The lidar team also returned to the Alaskan North Slope for several weeks in 2014 to conduct a large airborne lidar and imaging survey near Prudhoe Bay to assess thermokarst lake depths and volumes, and to characterize periglacial landforms.

Installation is complete for the Texas Soil Observation Network (TxSON), which consists of 39 soil-moisture and precipitation stations in the Texas Hill Country near Fredericksburg. In partnership with NASA's Jet Propulsion Laboratory, it will serve as a calibration and validation site for the Soil Moisture Active Passive (SMAP) satellite, which launched in January 2015. Data are transmitted in real time to the Bureau and are available at http://www.beg.utexas.edu/soilmoisture/.

A major new instrument was added to the NSO in 2014: a time-domain electromagnetic (EM) system (WalkTEM) that can be used to explore the electrical conductivity structure from the ground surface to depths of 200 m or more and is useful for Quaternary stratigraphic studies and water-resource investigations. The hyperspectral system was damaged in an aircraft crash before its first test flight and is currently under repair. The EM system has been field tested at the Cranfield CO_2 sequestration site in Mississippi and in a geologic mapping project on the central Texas coast.

Advanced Energy Consortium

Principal Investigators: Scott W. Tinker, Jay P. Kipper, David Chapman, and Mohsen Ahmadian



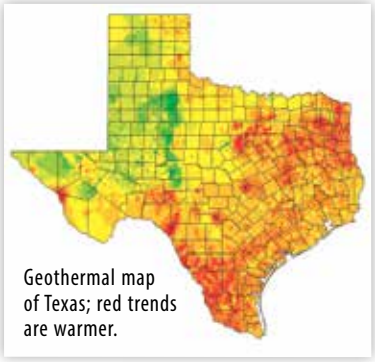
Advanced Energy Consortium's first-generation prototype multisensing microsystems shown here were developed by a team at the University of Michigan.

In 2014, the Advanced Energy Consortium (AEC) completed its 7th year of operation and continued to manage a diverse international portfolio of nanosensor projects on behalf of its members. Applied nano- and microscale subsurface sensor research is ongoing, with broad collaboration and funding to more than 30 universities around the world. The AEC also continues to focus research on five specific applications, including sensing applications to water flooding and hydrofracturing, as well as chemical enhanced oil recovery. These applications were selected by AEC membership as viable options for eventually helping them with the extraction of hydrocarbons, either through improved recovery or reduced cost. Multiple ideas are 1–2 years away from broad commercial development and deployment by or on behalf of AEC members.

This year, the AEC also continued to manage a growing list of publications and intellectual property on behalf of its members. The group has sponsored over 40 patents and 200 published manuscripts to date and has successfully established a new area of scientific research that merges nanotechnology and the oil and gas industry. The AEC also hosted several focused workshops in 2014, as well as two all-project reviews, in Boston and Houston, allowing over 150 researchers and consortium members to share ideas and discuss projects. With the group's cutting-edge research and collaborations, academic and industry leaders continue to acknowledge the AEC as a source of innovation and discovery.

Geothermal Energy Is Hot!

Principal Investigator: Bruce L. Cutright



Geothermal map of Texas; red trends are warmer.

The Bureau hosts a small team of innovative researchers who are certain that "unconventional geothermal" energy is the cheapest, cleanest way to meet Texas' electricity requirements for years to come. In an effort led by the Bureau's **Bruce Cutright**, Texas became the largest contributor of data to the newly launched U.S. Department of Energy National Geothermal Data System (NGDS), an online open-source platform that facilitates the discovery and use of geothermal data, enabling future researchers to speed geothermal energy development.

Why does geothermal energy make so much sense today? For one thing, the development of binary-cycle heat-exchanging systems, steam generators that use low-boiling-point refrigerants instead of water to produce steam, allows us to tap into much cooler heat sources than do traditional geothermal systems, which need to be located over geologic hot spots. These new binary-cycle generators need bottom-hole temperatures of only 200–400°F, and there are over 26,000 existing oil and gas wells in Texas alone that already meet that criterion. A pair of these wells circulating hot brines through a binary-cycle heat-exchanging system can produce electricity that is less expensive than that from any other renewable energy source (according to a recent Department of Energy analysis). This geothermal energy is also base-load, consistent power (not intermittent), and the process produces no CO_2.

"Every oil producer in the State should look at this as a way to extend the economic life of mature or watered-out fields with high reservoir temperatures," says Cutright. "Look at the benefits: a continuing income stream for the operator, royalties for the landowner, and severance taxes for the State—what's not to like!"

Fracture Research and Application Consortium

Principal Investigator: Stephen E. Laubach

Accurate fracture characterization and prediction is the goal of the Fracture Research and Application Consortium (FRAC). Understanding fractures in the deep subsurface is critical to accurate predictions of subsurface fluid flow and rock strength. Fluid flow in fractured rock is increasingly important in recovering water and hydrocarbon supplies and geothermal energy, in predicting flow of pollutants underground, in engineering structures, and in understanding large-scale crustal behavior. Fractures are exceedingly hard to sample in meaningful ways, and models to date have been hard to test, partly because fractures formed by different processes can look alike—if analysts don't know what to look for.

Rigorous application of fracture mechanics continues to yield insights. But for fractures in the deep subsurface, mechanics, no matter how complete, are inadequate. In the presence of reactive fluids like hot water, ubiquitous in the subsurface, chemical reactions are essential. Development of fracture arrays can usefully be thought of as a chemical transformation. Focusing on the geochemical reactions in fractures and surrounding rocks was a breakthrough that led to new, more effective and accurate ways of predicting and characterizing fractures; this approach is called *structural diagenesis*—a new research and training paradigm in sedimentary geochemistry and structural geology, and a key element in the FRAC program.

The recent focus of FRAC has been on unconventional and deep sandstone reservoirs, mudstone systems, and carbonate rocks. In parallel with this new area of focus on fault-rock structural diagenesis and fault attributes across a range of scales, the FRAC program seeks to develop practical tools that can be deployed in petroleum exploration and development. To those ends, FRAC tests methods on industry data sets, on timetables set by typical industrial operations, then rigorously evaluates the quality, timeliness, and economic value of the results. FRAC requires that testing of diagnostic and predictive approaches developed from outcrop, core, and well-test studies be ultimately cost effective and generally carried out in areas of interest to member companies.

The aims of this project are both fundamental and practical—to improve prediction and diagnosis of natural-fracture attributes in hydrocarbon reservoirs, accurately simulate their influence on production, and assess fractured reservoir response to stimulation operations (such as hydraulic fracturing). New analytical methods lead to more realistic characterization of fractured and faulted reservoir rocks. These methods produce data that can enhance well-test and seismic interpretations and that can readily be used in reservoir simulators.

Teamwork and integration of results from many disciplines are essential to the success of FRAC. The consortium is based on an alliance between scientists and engineers at the Bureau of Economic Geology and at the Petroleum and Geosystems Engineering (PGE) and Geosciences departments of The University of Texas at Austin.

Applied Geodynamics Laboratory

Principal Investigators: Martin P. A. Jackson and Michael R. Hudec

The Applied Geodynamics Laboratory (AGL) is dedicated to producing innovative new concepts in salt tectonics. This research comprises a mix of physical and mathematical modeling, seismic-based mapping, and structural-stratigraphic analysis of some of the world's most spectacular salt basins.

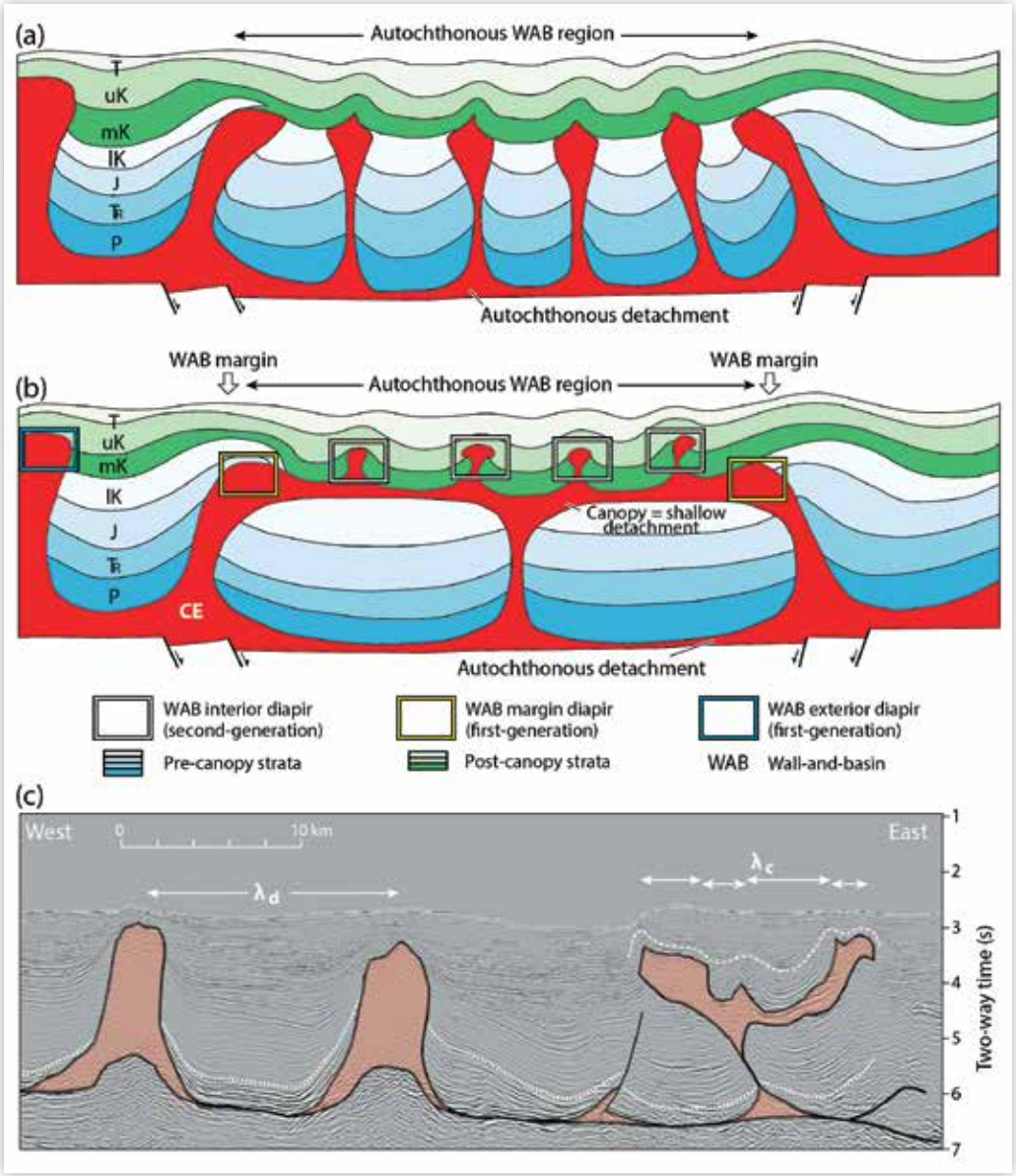
The AGL's physical-modeling program studies the evolution of salt structures on passive margins around the world. Key structural styles investigated in 2014 include bucket-welded minibasins, extensional keels beneath salt sheets, internal salt-flow patterns in salt canopies, and radial-fault arrays around salt domes. The goal of this modeling is to provide kinematic and geometric models that can be used by geophysicists to improve seismic interpretations.

The AGL's geomechanical-modeling effort studies stresses and fluid pressures around evolving salt structures. This year's research included investigations of the impact that source-layer welding has on stresses around salt domes, as well as of how near-feeder stresses change during emplacement of an overlying salt sheet.

These models are applicable for companies drilling wells in salt-flank and subsalt settings, where correct prediction of in situ stresses is critical.

The geological team is investigating how the opening of the South Atlantic Ocean affected the salt basins on either side of the rift. Studies in the Campos Basin, Brazil, show how stretching and separation of the salt layer deformed the overlying rocks, forming many of the structural and stratigraphic traps that are current targets for hydrocarbon exploration and production.

Finally, the AGL is actively collaborating with researchers from around the globe. Current efforts include projects with the University of Colorado, the National Oceanography Centre (Southampton), Imperial College (London), and Université de Pau et des Pays de l'Adour (Pau). These projects ensure that the AGL stays on the cutting edge of modern salt-tectonic research.



State of Texas Advanced Resource Recovery Program

Principal Investigator: William A. Ambrose

The goal of the State of Texas Advanced Resource Recovery (STARR) program is to increase royalty and severance tax income to the State from oil and gas production within Texas. During the 2012–2014 biennium, the STARR program was revenue positive by a net factor of 15.6x, chiefly because of several thousand successful wells drilled in the highly productive Eagle Ford Shale play in South Texas and the tight-oil Spraberry-Wolfcamp (Wolfberry) play in the Permian Basin, as well as other active plays such as the Frio Formation of the Gulf Coast.

A wide variety of new reservoir characterization projects (field studies) and eight new regional studies contributed to the successful completion of new wells and improved oil- and gas-recovery strategies. Study areas include the Woodbine Group in Cherokee, Rusk, Tyler, Polk, and Navarro counties; the Marble Falls Formation in Jack County; the Cline Shale and Wolfcamp formations in Howard and Glasscock counties; the Glorieta Formation in Ward County; the Eaglebine Trend in Leon, Madison, and Fayette counties; and the Frio Formation in Nueces County and adjacent areas.

A regional study of the Eaglebine Trend in southeast Texas focused on a play where recent horizontal wells have produced oil and gas in heterogeneous, low-permeability, distal-deltaic deposits in the Woodbine Group. Results will be released in an upcoming issue of the American Association of Petroleum Geologists *Bulletin*.

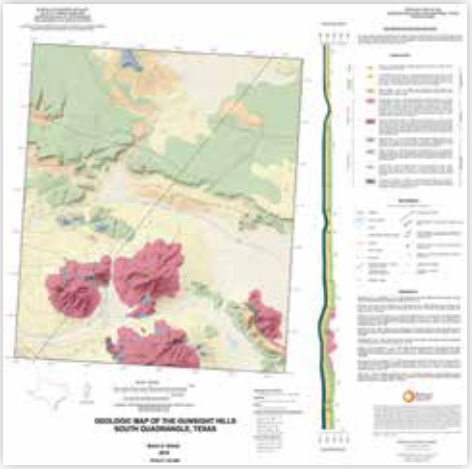
In 2014, the STARR program completed additional projects contributing to the understanding of Texas resources and associated environmental concerns, including research on geothermal resources, minerals mapping, geological hazards mapping, energy economics, drought vulnerability, and coastal habitat monitoring.

Geologic Mapping

Principal Investigator: Edward W. Collins

The Bureau provides Texas with a geologic-map database and related information that serves as a primary data source for applied earth-science investigations. Maps address State needs such as (1) planning and managing land use; (2) studying erosion, sedimentation, and habitat changes of coastal environments; (3) developing earth and mineral resources; (4) studying aquifer recharge; (5) evaluating unconventional shale oil and gas exploration/production areas; and (6) studying Texas geologic hazards. Bureau 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 studies mineral and earth resources and geologic hazards.

Researchers **Eddie Collins, Brent Elliott, Jeff Paine**, and **Chock Woodruff** conducted geologic mapping for Bureau projects in 2014. The seven maps produced include the Aransas and Mission deltas of the Copano Bay area, to support ongoing studies of shoreline changes and fluvial-deltaic deposition, and provide baseline data for the planning and management of land use. Other 2014 Bureau maps explore the potential economic development of mineral/earth resources in Texas, including (1) West Texas areas with occurrences of rare earth elements; (2) South Central Texas areas with new sand and gravel resources for road construction, cement production, and hydraulic fracturing; and (3) a North Central Texas area where sand and limestone are quarried. Ongoing and planned geologic mapping involves statewide economic development of mineral and earth resources.



Quantitative Clastics Laboratory

Principal Investigator (acting): Peter P. Flaig

The Bureau's Quantitative Clastics Laboratory (QCL), whose mission includes providing its member companies with reservoir analogs and investigating petroleum systems for both academia and industry, continues to grow into what could be considered the best academic-based clastic research program in the world. This year the QCL continued its cutting-edge research in fluvial-deltaic shallow-marine and deepwater systems, in addition to maintaining and continuously updating one of the largest databases of clastic reservoir analogs available. Recent or ongoing investigations using outcrop exposures; subsurface core, well logs, and seismic; and remotely sensed surface data sets include the following:

- Using outcrops of the Schrader Bluff and Prince Creek formations on the North Slope of Alaska as analogs for shallow reservoirs. Identifying depositional environments at the marine to continental transition that include wave-storm dominated shorelines, muddy deltas, and fluvial feeder systems.
- Providing outcrop analogs and reservoir models for highly variable systems such as the Blackhawk, Sego, and Loyd formations of Utah and Colorado, which preserve wave, tide, and river-dominated systems along complex coastlines.
- Continuing an investigation into the sealing capacity of mass transport complexes, which should aid in the reevaluation of depositional and reservoir models for these deposits.
- Completing a study on the effects on lithospheric structures and overlying clastic basin evolution and fill in the southeastern Caribbean subduction to strike-slip transition zone, with significant applications to industry.
- Studying the change in facies and stacking patterns across the Permian–Triassic boundary in Antarctica that is revealing submarine-shelf channels, levees, lobes, river-dominated deltas, braided streams, and coal measures. This study of a tectonically active basin also has implications for oil and gas reservoirs in related basins, including the Bowen, Karoo, and Paraná.
- Using remotely sensed data to measure the morphology of modern rivers, analyze influences on river width and sinuosity across the conterminous United States, and calculate river-groundwater exchange rates across the Mississippi River drainage basin.
- Using satellite imagery in the Cretaceous McMurray Formation of Alberta, Canada, to produce a new classification scheme for washover fans to improve reservoir models. Subsurface analysis provided evidence of bedrock-controlled flood-tidal deltas.
- Using the storm-dominated Cape Sebastian Sandstone in the Pacific Northwest, along with other Cretaceous strata and modern deposits from Hurricane Sandy, to model hummocky cross-stratification and sediment transport along the shelf.
- Studying the use of near-seafloor high-resolution geophysical data to understand the interaction between gravity-driven and current-controlled processes in deepwater and ultra-deepwater environments, focusing on the lower continental slope to abyssal-plain transition of the central Gulf of Mexico basin.

High-resolution GigaPan photomosaic of wave- and storm-dominated deposits within the Grassy Member of the Blackhawk Formation. Submarine canyon north of Tusher Canyon, Utah. (Persons for scale—can you find the two geologists in this photo?)

Awards and Honors

Bureau Named a "Top Workplace"

For the second time in 3 years, the *Austin American-Statesman* survey of area employees has named the Bureau of Economic Geology as one of a handful of "Top Workplaces" in the city for 2014. With 120 researchers (representing 27 countries), 50 support staff, and a broad reputation as a world leader in energy and environmental research, the Bureau is the oldest and second-largest research unit at The University of Texas at Austin.

Bureau director **Scott W. Tinker** said, "I'm really gratified that we have been honored in this way again. It shows that our researchers and staff continue to feel that the Bureau is a productive place to work, that they enjoy the family atmosphere that we strive to achieve, and that they're having fun! This honor is a tribute to each of them and to their tremendous contributions to the success of the Bureau of Economic Geology."

The *Austin American-Statesman* survey was conducted by Workplace Dynamics LLC. Employers named as "Top Workplaces" were first nominated by their employees and then selected by analysis of employee responses to the survey.

Shirley Dutton accepts her medal from GCSSEPM president Carl Fiduk.

Doris M. Curtis Medal: Shirley Dutton

Shirley Dutton received the **2014 Doris M. Curtis Medal** from the Gulf Coast Section of the Society for Sedimentary Geology (GCSSEPM) for her "outstanding contributions to our understanding of the Gulf of Mexico Sedimentary Basin and other basins worldwide." GCSSEPM president J. Carl Fiduk presented the medal to Dutton at the 2014 Gulf Coast Association of Geological Societies (GCAGS) convention. A Senior Research Scientist at the Bureau, Dutton co-directs the Deep Shelf Gas Consortium; her current research involves diagenesis of deep to ultradeep sandstones of the Gulf of Mexico. The award, named for Doris Malkin Curtis, a pioneer in studies of Gulf Coast geology, was established by the GCSSEPM in 2007.

Norman Falcon Award: Darrin Burton and Lesli Wood

Darrin Burton (Quantitative Clastics Laboratory Research Fellow) and **Lesli Wood** (QCL Principal Investigator) received the **2014 Norman Falcon Award** for their paper "Geologically-based permeability anisotropy estimates for tidally-influenced reservoirs using quantitative shale data," published in the February 2013 issue of *Petroleum Geoscience*. The award is presented by the European Association of Geologists and Engineers (EAGE) for the best paper published in *Petroleum Geoscience* in the preceding calendar year.

GCAGS Journal President's Award for Outstanding Paper: Jerry Lucia and Bob Loucks

Senior Research Scientists **Jerry Lucia** and **Bob Loucks** received the **2013 President's Award for Outstanding Paper in the *GCAGS Journal*** for "Micropores in Carbonate Mud: Early Development and Petrophysics." Their study, based on core taken from the Clino well on the western slope of the Great Bahama Bank, focuses on the early transformation of a depositional lime mud to a microporous microspar fabric.

Lucia, who is retired but still works part time for the Bureau, is an internationally known expert in carbonate reservoir geology, reservoir characterization, petrophysics, and reservoir modeling. Loucks' present research includes deeply buried reservoirs in the Gulf of Mexico; evaporite and carbonate paleokarst; and pore networks in carbonates, sandstones, and mudrocks.

Bureau Publication Awards: Sergey Fomel and Other First Authors

Sergey Fomel earned the **2014 Tinker Family BEG Publication Award** "for his exemplary publication record in exploration geophysics and his dedication to the development of the open-source software Madagascar," as demonstrated in the 2013 *Geophysical Prospecting* paper, "Seismic wave extrapolation using lowrank symbol approximation" (S. Fomel, L. Ying, and X. Song). The award was established "to recognize exemplary publications of demonstrated or expected scientific or economic impact, or those that otherwise increase the visibility of the BEG scientific community."

Bureau researchers were prolific in 2013, with more than 100 peer-reviewed publications featured in academic journals worldwide. A total of 45 Bureau first authors accounted for 70 of these publications; these distinguished authors were also honored at the Bureau's Publication Awards Dinner. **Sergey Fomel, Alex Sun,** and **Changbing Yang** had the greatest number of first-author, peer-reviewed papers in 2013, with four each. **Bill Ambrose** and **Bob Loucks** shared the distinction of being honored 6 years in a row, every year since the inception of the Bureau's awards program.

Society of Exploration Geophysicists Awards: Fomel, Chen, and Sripanich

The Society of Exploration Geophysicists (SEG) recognized three Bureau members for their excellent technical presentations at the 2014 SEG Annual Meeting in Denver. Papers by **Sergey Fomel**, **Yangkang Chen**, and **Yanadet Sripanich** were ranked among the "top 30 papers" presented. This is the 13th such honor for Fomel.

Council on Earth Sciences Appointment: Steve Laubach

Senior Research Scientist **Steve Laubach** has been appointed to the **Council on Earth Sciences** for a 6-year term. The Council, sponsored by the U.S. Department of Energy (DOE) Office of Basic Energy Sciences, plays an important role in monitoring cutting-edge science, and in planning and conducting workshops on science areas that have long-term relevance for DOE mission strategies. Composed of scientists from national laboratories and universities, the Council gathers twice a year to discuss DOE Geosciences activities across the agency.

Geosciences in the Media Award: Scott W. Tinker

Bureau director **Scott W. Tinker** and Harry Lynch, co-producer and director of the global-energy documentary film *Switch*, together received the AAPG's **Geosciences in the Media Award**. The award is presented "in recognition of notable journalistic achievement in any medium which contributes to public understanding of geology, energy resources, or the technology of oil and gas exploration." The *Switch* Energy Project has reached millions of viewers around the world through the film, its online outreach, and its broad energy-education efforts.

Grover E. Murray Memorial Distinguished Educator Award: Charlie Kerans

Senior Research Scientist **Charlie Kerans** has been selected for the AAPG's **Grover E. Murray Memorial Distinguished Educator Award**, which is given in recognition of distinguished and outstanding contributions to geological education. Kerans, who holds the Robert K. Goldhammer Chair in Carbonate Geology in the Jackson School of Geosciences, says, "I enjoy demonstrating to my students their wisdom in studying sedimentary geology, a field that offers fascinating subject matter and welcoming cohorts."

Robert R. Berg Award and Karst Award: Bob Loucks

At its 2014 Annual Convention and Exhibition, the AAPG presented Senior Research Scientist **Bob Loucks** with its **Robert R. Berg Outstanding Research Award**, "for his key research in characterizing pore systems in hydrocarbon-bearing sedimentary successions and his ability to enthusiastically communicate these findings to the geoscience community." The award, given in recognition of a singular achievement in petroleum geoscience research, is the AAPG's fifth highest award.

This year, Loucks also received the **2014 Karst Waters Institute (KWI) Award** for his research on the relationship between paleo-karst and hydrocarbon reservoirs. The Karst Award was first presented in 1999 to recognize individuals who have had a considerable impact on karst science and research. Loucks accepted his award at the March 2014 Karst Award Banquet in Houston, where he gave an invited talk on "How Modern Karst Studies Lead to Understanding the Development and Burial Evolution of Paleokarst Reservoirs."

Charles J. Mankin Memorial Award: Scott Hamlin and Robert Baumgardner

The Bureau's **Scott Hamlin** and **Robert Baumgardner** were named recipients of the **2014 Charles J. Mankin Memorial Award** by the Association of American State Geologists (AASG). The award recognizes the outstanding state geological survey publication with an emphasis on surface or subsurface geologic mapping, compilations, and associated reports. Hamlin and Baumgardner's Report of Investigations No. 277, *Wolfberry (Wolfcampian-Leonardian) Deep-Water Depositional Systems in the Midland Basin: Stratigraphy, Lithofacies, Reservoirs, and Source Rocks*, has been among the Bureau's best sellers since its publication in 2012.

Hats Off! Award: Scott W. Tinker

TIPRO's former chair David F. Martineau and Scott W. Tinker.

The Texas Independent Producers and Royalty Owners Association (TIPRO) presented its **2014 Hats Off! Award** to Bureau director **Scott W. Tinker** at its 68th Annual Convention in March. TIPRO periodically recognizes individuals who have taken exceptional strides to help ensure continued safe and responsible hydrocarbon development in Texas. Tinker was recognized "for his tireless pursuit of truth through science and education; for his leadership in examining the intersection of energy, the environment, and the economy; for his research endeavors in fields of study vital to the oil and natural gas industry; for his dedication in striving for Texas excellence; and for his service to the citizens of Texas."

AGU Fellow: Bridget Scanlon

The American Geophysical Union (AGU) has named the Bureau's **Bridget Scanlon** a **2014 AGU Fellow** for "new understanding of plant, land use, and climatic effects on soils, salts, and groundwater resource sustainability in arid and semiarid lands." The honor recognizes AGU members who have attained acknowledged eminence in the Earth and space sciences. Primary criteria for evaluating scientific eminence are a major breakthrough or discovery, paradigm shift, or sustained impact. This year's class of 62 Fellows is less than 0.1% of the total AGU membership worldwide.

Using a 3D microscope, Greg Frébourg demonstrates small-scale sedimentary features of the organic-matter-rich 13 Fingers Formation (Anadarko Basin, Texas Panhandle).

Bureau Engages at Industry Day

Where can you learn about the latest Bureau research, hear from fascinating speakers, mingle with guests from companies and agencies large and small, and have Texas barbecue among the rocks of one of the largest core collections in the world? Nowhere else but the Bureau's Industry Day! The 2014 event, "**Discovering the Bureau: Energy, Economics, and the Environment**," was held in April at Austin's Core Research Center. Over 65 guests from 33 companies and 8 State agencies experienced firsthand the breadth of Bureau research by talking to researchers and students who presented 38 posters featuring everything from new findings in carbon capture and storage to pore structures in shale plays.

Highlights of this year's Industry Day included guest speakers **Scott Anderson** of the Environmental Defense Fund and **Peter Duncan** of MicroSeismic, who presented new information in their respective fields. In addition, Associate Director **Eric Potter** unveiled plans for a new West Texas Resource Initiative during Industry Day's special session. The annual event accomplished its goal of informing a broad spectrum of industry and agency representatives about new ways to engage with the Bureau.

Bureau On Hand for Petra Nova Groundbreaking

Bureau of Economic Geology researchers are heavily involved in the new Petra Nova Carbon Capture System, which recently broke ground in Fort Bend County, Texas. Among the dignitaries present at the groundbreaking were Scott W. Tinker, director of the Bureau, and **Susan Hovorka**, principal investigator of the Gulf Coast Carbon Center (GCCC).

Petra Nova, a joint venture between NRG and JX Nippon Oil & Gas Exploration, is being constructed to capture CO_2 produced from the W. A. Parish power plant, a massive coal-burning facility. An estimated 1.6 million tons of CO_2 per year will then be injected via an enhanced oil recovery (EOR) operation into Hilcorp's West Ranch oil field in Jackson County. The Bureau's GCCC will monitor the first 3 years of geologic storage of the injected CO_2.

The system is projected to be fully operational by mid-2016. When complete, it will be the largest post-combustion CO_2-capture project in an existing coal-fueled power plant in the United States. The project was selected by the Department of Energy (DOE) through its Clean Coal Power Initiative Program (CCPI) to receive $167 million in funding.

The Bureau has been assisting Petra Nova with planning for the upcoming operations phase since 2010, including contributions to the original DOE proposal, support with EOR site suitability and characterization, and help with the application for National Environmental Policy Act (NEPA) approval. GCCC researchers, including **Vanessa Nuñez-Lopez** and **Rebecca Smyth,** have played significant roles in the planning and implementation of the project.

Bureau Symposium Features Innovative Posters

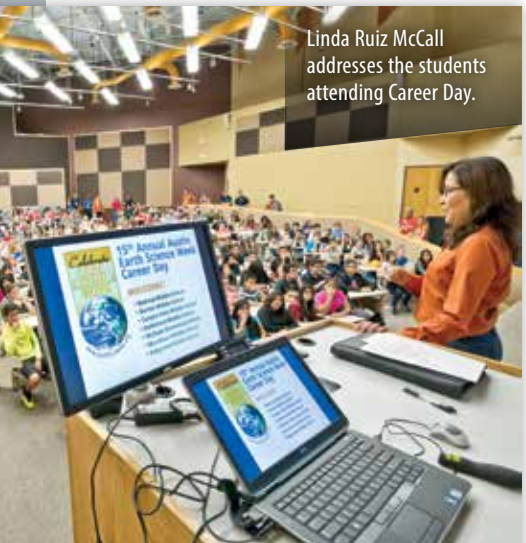
The 2nd Annual Bureau Research Symposium, held in September, featured over 30 posters showcasing novel research. Poster topics included aerial salinity surveys, marine seismic applications, nanosensors, and massive undersea flow. **Tim Dooley, Martin Jackson,** and **Michael Hudec** won Best Overall (Energy Research) with their "Squeezing a Large Canopy on a Slope: Suturing Patterns, Subsalt Thrusting, Suprasalt Extension and Salt Expulsion." The poster also won awards for Most Ground-Breaking Research and Best Use of Color. **Alexander Sun, Bridget Scanlon,** and **Kristine Uhlman** won Best Overall (Environmental Research) for their "Enabling Environmental Management Decision Support and Public Outreach Using Cloud-Computing Services" poster. **Maria Nikolinakou**'s poster won the award for Best Feedback Device.

JSG Dean Sharon Mosher studies the work of Rob Reed.

Education and Outreach Key Aspects of Bureau's Service

Resource Center

The Bureau's Resource Center provides geologic information to the geoscience community, educators, and the public through its Public Information Office, Geophysical Log Facility, Map Room, and Texana Library, as well as The Bureau Store, which features publications by Bureau researchers. The Resource Center is open weekdays from 8 a.m. to 12 p.m. and from 1 p.m. to 5 p.m. Bureau Information Geologist **Linda Ruiz McCall**, who also serves on the Texas Groundwater Protection Committee, is the Center's manager. For more information: http://www.beg.utexas.edu/info/res_ctr.php.



Linda Ruiz McCall addresses the students attending Career Day.

Science Teachers Conference

The Bureau's **Linda Ruiz McCall** and **Scott Rodgers** reached more than 150 Texas science teachers

in professional development workshops at the Conference for the Advancement of Science Teaching (CAST) held in Dallas in November. McCall was also the keynote speaker for the 30th Annual Texas Earth Science Teachers Association (TESTA) dinner during the conference. In support of TESTA's Sharathon, the Bureau donated 60 Earth Science Week toolkits and Bureau map sets to earth science teachers. McCall and Rodgers also distributed hundreds of Bureau maps and information sheets to conference attendees.

Explore UT

Bureau staff joined in the Explore UT campus open-house activities for the Jackson School of Geosciences in March. The annual event aims to inform the public about The University of Texas mission of teaching, research, and public service. Bureau-led activities at Explore UT included "What To Do with CO_2," "Cure for the Feverish Earth," "Find Gold," and

"3D Geology Visualizations." Bureau staff volunteering at the event included **Jan Braboy, Heather Christensen, Sharon Campos, Sara Clough, Ursula Hammes, Sue Hovorka, Seunghee Kim, Kim LaValley, Linda Ruiz McCall, Mahdi Moghadam, Prisca Ogbuabuo, Johnathon Osmond, Reuben Reyes,** and **Valerie Siewert.**

Earth Science Week Career Day

The Bureau hosted the 15th Annual Earth Science Week Career Day in October. Over 350 middle-school students from the Austin area came to the J. J. Pickle Research Campus for a day of presentations, exhibits, and face-to-face interaction with 70 geoscience professionals. In addition to Bureau staff, participating organizations included the U.S. Geological Survey, the Austin Geological Society, Statoil, Schlumberger, the Lower Colorado River Authority Employees' United Charities, and the Jackson School of Geosciences.

Texas High School Coastal Monitoring Program

In 2014, the Texas High School Coastal Monitoring Program, led by **Tiffany Caudle**, marked 17 years of engaging residents of the Texas coast in the study of their natural environment. Bureau scientists provide the tools and training needed for students and teachers to learn how to measure the topography, map the vegetation line and shoreline, and observe weather and wave conditions.

Kitty Milliken leads a GeoFORCE trip to the Guadalupe Mountains in West Texas.

GeoFORCE

Bureau scientists **Tiffany Caudle, Peter Flaig, Greg Frébourg, Kitty Milliken,** and **Jeffrey Paine** joined University faculty and industry partners to lead over 600 Texas students on spectacular field trips for the Jackson School's GeoFORCE program. Since 2005, the program has proven successful in preparing Texas high school students to become part of the geosciences workforce.

3D Visualization Team

The Bureau's 3D Visualization team was busy in 2014, with presentations at 11 events, including for the Hill Country Science Mill in Johnson City, Hill Country Alliance, prospective students in surface and hydrologic processes, and visitors from Abu Dhabi University. Visualization team members from the Bureau include **John Andrews** and **Scott Rodgers**.

Chock Woodruff instructs middle-school students during Career Day.

Presentation for the Hill Country Science Mill. Participants donned 3D glasses to view 3D models of subsurface reservoirs.

The Bureau Store

The official store of the Bureau of Economic Geology

The Bureau Store, the official store of the Bureau of Economic Geology, serves the geoscience community, educators, and the general public by offering more than 2,000 books, maps, and digital products published by the Bureau's research staff. 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 societies, and the Gulf Coast Section of SEPM (GCSSEPM). Items on the store's List of Publications (http://www.beg.utexas.edu/pubs/LOP.pdf) can be purchased online (http://begstore/beg.utexas.edu/store/) or at the J. J. Pickle Research Campus in North Austin. Contact store staff members **Amanda R. Masterson** and **Dennis J. Campa** at pubsales@beg.utexas.edu or by phone at 512-471-7144.

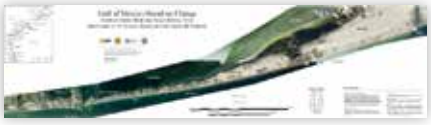
Book

Tectonostratigraphy and Allochthonous Salt Tectonics of Axel Heiberg Island, Central Sverdrup Basin, Arctic Canada: Harrison, J. C., and Jackson, M. P. A., 2014, The University of Texas at Austin, Bureau of Economic Geology Report of Investigations No. 279, 124 p.

The authors examine Axel Heiberg Island (northern Nunavut), which contains the thickest Mesozoic section in the Sverdrup Basin. The island, only 370 km long, is second only to Iran in its concentration of exposed diapirs: 46 diapirs of Carboniferous evaporites and associated minibasins. The Axel Heiberg canopy is one of only three known exposed evaporite canopies.

Posters: Gulf of Mexico Shoreline Change

Long-term rates of Gulf shoreline movement along the Texas coast have been determined through 2012 from a series of shoreline positions that includes those depicted on aerial photographs from the 1930's to 2007, ground GPS surveys, and airborne lidar surveys in 2000 and 2012. Net rates of long-term shoreline movement measured at 11,749 sites spaced at 164 ft (50 m) along the 332 mi (535 km) of Texas shoreline fronting the Gulf of Mexico average 4.1 ft/yr (1.26 m/yr) of retreat. For readability, these posters show every third data point at an alongshore interval of 492 ft (150 m).



Gulf of Mexico Shoreline Change, Southern Padre Island and Brazos Island, Texas: Rio Grande (U.S./Mexico Border) to Port Mansfield Channel: Caudle, T. L., Paine, J. G., Andrews, J. R., and Suarez, J., 2014, The University of Texas at Austin, Bureau of Economic Geology, Poster, PS0010, scale 1:24,000.

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Gulf of Mexico Shoreline Change, Eastern Matagorda Peninsula, Texas: Colorado River to Brazos River: Caudle, T. L., Paine, J. G., Andrews, J. R., and Suarez, J., 2014, The University of Texas at Austin, Bureau of Economic Geology, Poster, PS0011, scale 1:24,000.

Gulf of Mexico Shoreline Change, Bolivar Peninsula, Texas: Bolivar Roads to High Island: Caudle, T. L., Paine, J. G., Andrews, J. R., and Suarez, J., 2014, The University of Texas at Austin, Bureau of Economic Geology, Poster, PS0012, scale 1:24,000.

Gulf of Mexico Shoreline Change, Mustang Island and North Padre Island, Texas: Northern Padre Island to Aransas Pass: Caudle, T. C., Paine, J. G., Andrews, J. R., and Suarez, J., 2014, The University of Texas at Austin, Bureau of Economic Geology, Poster, PS0013, scale 1:24,000.

Gulf of Mexico Shoreline Change, Galveston Island, Texas: San Luis Pass to Bolivar Roads: Caudle, T. L., Paine, J. G., Andrews, J. R., and Suarez, J., 2014, The University of Texas at Austin, Bureau of Economic Geology, Poster, PS0014, scale 1:24,000.

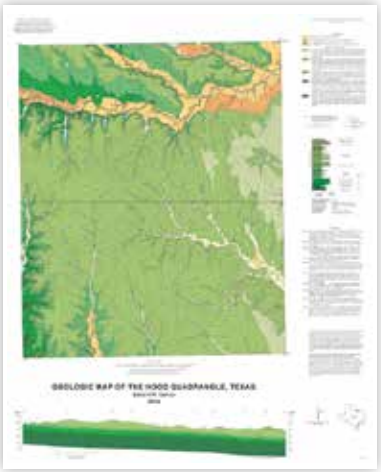
Gulf of Mexico Shoreline Change, Brazos River to San Luis Pass, Texas: Caudle, T. L., Paine, J. G., Andrews, J. R., and Suarez, J., 2014, The University of Texas at Austin, Bureau of Economic Geology, Poster, PS0015, scale 1:24,000.

Gulf of Mexico Shoreline Change, High Island to Sabine Pass, Texas: Caudle, T. L., Paine, J. G., Andrews, J. R., and Suarez, J., 2014, The University of Texas at Austin, Bureau of Economic Geology, Poster, PS0016, scale 1:24,000.

Gulf of Mexico Shoreline Change, Western Matagorda Peninsula, Texas: Pass Cavallo to Colorado River: Caudle, T. C., Paine, J. G., Andrews, J. R., and Suarez, J., 2014, The University of Texas at Austin, Bureau of Economic Geology, Poster, PS0017, scale 1:24,000.

Maps

Geologic Map of the Hood Quadrangle, Texas: Collins, E. W., 2014, The University of Texas at Austin, Bureau of Economic Geology, Open-File Map, OFM0209, scale 1:24,000.



This quadrangle is one of several for the mapping study of the North Central Texas transportation corridor north of the Fort Worth area. Maps for this corridor 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 units exposed across this corridor comprise about 1,500 ft of Cretaceous shelf and shore-zone deposits, including the upper Antlers sand, clay, and conglomerate; Walnut limestone and marl; Goodland limestone; Kiamichi marl and clay; Duck Creek limestone; and Forth limestone. Goodland limestone and Antlers sand are potential earth resources and are quarried in adjacent areas. Antlers deposits in the subsurface compose the Trinity Aquifer, a major aquifer of the region.

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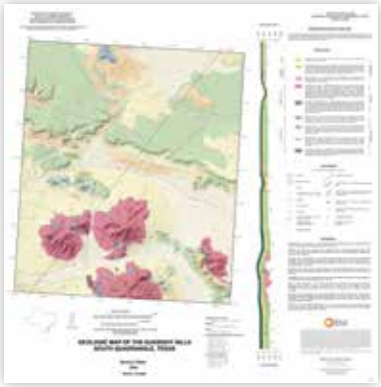
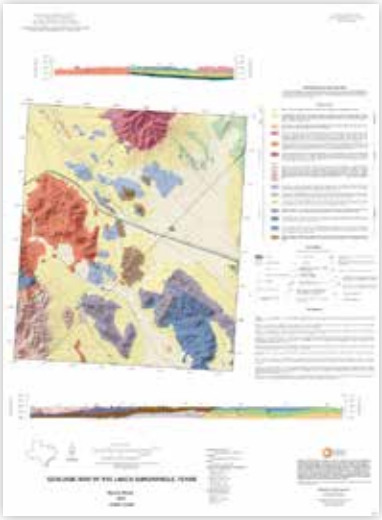


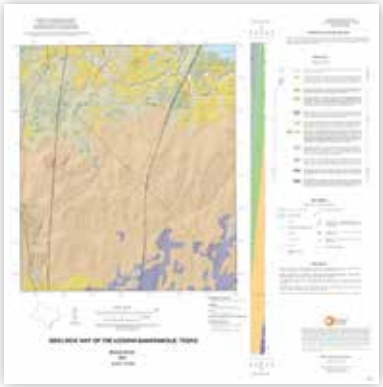
Geologic Map of the Gunsight Hills South Quadrangle, Texas:
Elliott, B. A., 2014, The University of Texas at Austin, Bureau of Economic Geology, Open-File Map, OFM0211, scale 1:24,000.

This map is one of several 1:24,000-scale maps of the Trans-Pecos region, focusing on mineral resources associated with Tertiary intrusives and volcanic rocks of West Texas. Maps for this region provide a basic geologic framework to aid in managing water and earth resources; planning land use; and identifying sources of rare earth elements, precious and base metals, uranium, thorium, fluorine, beryllium, and other earth resources. This study area covers Tertiary hypabyssal rhyolite laccoliths and volcanic rocks north of the Sierra Blanca peak, including the Round Top rare-earth-element prospect, Little Round Top, Little Sierra Blanca, and Triple Hill subvolcanic rhyolite laccoliths within and overlying Cretaceous Cox sandstone and Finlay and Buda limestone stratigraphy. The Tertiary intrusive and volcanic rocks provide excellent potential for hydrothermal mineral resource formation, skarn development, and magmatic ore resources in West Texas.



Geologic Map of the Lasca Quadrangle, Texas: Elliott, B. A., 2014, The University of Texas at Austin, Bureau of Economic Geology, Open-File Map, OFM0212, scale 1:24,000.

This map is one of several 1:24,000-scale maps of the Trans-Pecos region, focusing on mineral resources associated with Tertiary intrusives and volcanic rocks of West Texas. Maps for this region provide a basic geologic framework to aid in managing water and earth resources; planning land use; and identifying sources of rare earth elements, precious and base metals, uranium, thorium, fluorine, beryllium, and other earth resources. This study area covers Tertiary hypabyssal rhyolite laccoliths and volcanic rocks south of the Sierra Blanca peak, and the east side of the Quitman Mountain caldera system, within and overlying Cretaceous Cox sandstone, Finlay and Buda limestone, Etholen conglomerate, and Bluff Mesa limestone stratigraphy. The Tertiary intrusive and volcanic rocks provide excellent potential for hydrothermal mineral resource formation, skarn development, and magmatic ore resources in West Texas.



Geologic Map of the Losoya Quadrangle, Texas: Elliott, B. A., 2014, The University of Texas at Austin, Bureau of Economic Geology, Open-File Map, OFM0213, scale 1:24,000.

This map is one of several 1:24,000-scale maps of the region south of San Antonio, focusing on sand resources in the Tertiary stratigraphy of South Central Texas. Maps for this region provide a basic geologic framework to aid in managing water and earth resources; planning land use; identifying aquifer recharge areas; and identifying sources of aggregate, sand, gravel, and other earth resources. This study area lies within an Eocene-age Carrizo-Wilcox fluvial-deltaic setting to transitional marine transgressional Reklaw Formation and Queen City Sand. The Carrizo Formation is an important sand resource in South Central Texas, and the Carrizo-Wilcox aquifer recharge zone is important for water resource management in the region.

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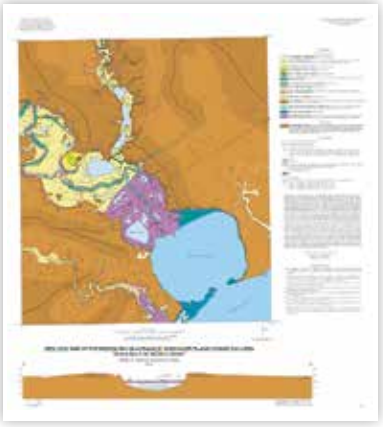
Geologic Map of the Bayside Quadrangle: Aransas Delta and Copano Bay Area, Texas Gulf of Mexico Coast: Paine, J. G., and Collins, E. W., 2014, The University of Texas at Austin, Bureau of Economic Geology, Open-File Map, OFM0214, scale 1:24,000.

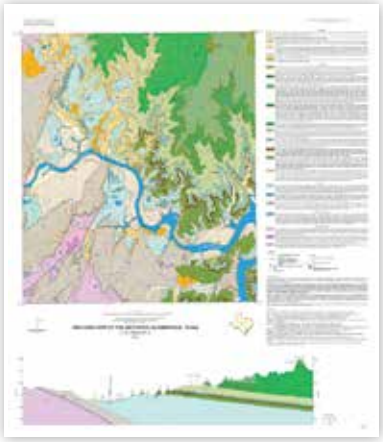
This map is one of four 1:24,000-scale maps of the Aransas and Mission deltas area, Texas Gulf of Mexico Coast. This study area lies within modern-to-Holocene Aransas and Mission fluvial-deltaic and bay/estuary settings. Here, the Aransas and Mission river valleys dissect Pleistocene fluvial-deltaic deposits of the Beaumont Formation. The map of the Bayside Quadrangle depicts the geology for the area where the Aransas delta progrades into the western margin of Copano Bay. Geology of this area partly consists of 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. The area also includes part of the upper Beaumont Formation barrier facies, Ingleside deposits. Modern-to-Holocene delta plain and bay margin deposits and tidal flats are adjacent to Copano Bay.

Geologic Map of the Mission Bay Quadrangle: Mission Delta and Copano Bay Area, Texas Gulf of Mexico Coast: Paine, J. G., and Collins, E. W., 2014, The University of Texas at Austin, Bureau of Economic Geology, Open-File Map, OFM0215, scale 1:24,000.



The geologic map of the Mission Bay Quadrangle is another 1:24,000-scale map illustrating the geology of the Aransas and Mission deltas area, Texas Gulf of Mexico Coast. The map of this quadrangle depicts an area where the Mission delta prograded into Mission Bay during the mid-to-late Holocene. Geology of the area partly consists of 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. Modern-to-Holocene fluvial floodplain, levee, crevasse splay, point bar, clay dune, and terrace deposits occur within the Mission River valley. Delta plain and bay margin deposits are adjacent to Mission Bay.

Geologic Map of the Smithwick Quadrangle: Woodruff, C. M., Jr., 2014, The University of Texas at Austin, Bureau of Economic Geology, Open-File Map, OFM0216, scale 1:24,000.



The Smithwick Quadrangle of Burnet County straddles the Colorado River along the impounded upper reaches of Lake Travis. Quaternary alluvial deposits (sand, gravel, silt, and clay) occur as terraces above lake level and as discontinuous valley deposits along tributary streams. The map shows a major unconformity between Cretaceous and Paleozoic strata. Cretaceous units in this area include: Sycamore Sand, Hammett Shale, Cow Creek Limestone, Hensel Sand, Glen Rose Limestone, discontinuous Paluxy Sand, Walnut Formation, Comanche Peak Limestone, and Edwards Limestone. Pennsylvanian strata (Smithwick Shale, Smithwick Sandstone, and Marble Falls Limestone) directly underlie the Cretaceous section. In places, these Paleozoic rock units are displaced by normal faults that trend northeast–southwest and locally juxtapose the upper Paleozoic strata against lower Paleozoic units (Ordovician Ellenburger Group and Cambrian San Saba Limestone).

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2014 Peer-Reviewed Publications by Bureau Researchers

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Ambrose, W. A., 2014, Coal, *in* Warwick, P. D., and Hackley, P. C., eds., Unconventional energy resources: 2013 review: Natural Resources Research, v. 23, no. 1, p. 20–23, http://doi.org/10.1007/s11053-013-9224-6.

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Bedayat, H., and Dahi Taleghani, A., 2014, Interacting double poroelastic inclusions: Mechanics of Materials, v. 69, no. 1, p. 204–212, http://doi.org/10.1016/j.mechmat.2013.10.006.

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DeAngelo, M., and Hardage, B. A., 2014, Application of 3C/3D converted mode reflections, King County, Texas: Interpretation, v. 2, no. 2, p. SE39–SE45, http://doi.org/10.1190/INT-2013-0181.1.

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Duncan, I. J., and Wang, H., 2014, Evaluating the likelihood of pipeline failures for future offshore CO_2 sequestration projects: International Journal of Greenhouse Gas Control, v. 24, p. 124–138, http://doi.org/10.1016/j.ijggc.2014.02.004.

Dutton, S. P., and Loucks, R. G., 2014, Reservoir quality and porosity-permeability trends in onshore Wilcox sandstones, Texas and Louisiana Gulf Coast: application to deep Wilcox plays, offshore Gulf of Mexico: GCAGS Journal, v. 3, p. 33–40.

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(continued on page 31)

Hardage, B. A., and Wagner, D. E., 2014, Generating direct-S modes with simple, low-cost, widely available seismic sources: Interpretation, v. 2, no. 2, p. SE1–SE15, http://doi.org/10.1190/INT-2013-0095.1.

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Transitions

John Ames, Computer Illustrator in the Bureau's Media department, retired in 2014. He began his career at the Bureau in 1980 as a pen-and-ink draftsman and traditional cartographer. In his early days, it often took months and a steady hand to produce the color separations for many of the Bureau's complex maps. Examples of his projects include a number of color maps in the popular *Geologic Atlas of Texas* (GAT) series and the four-sheet Tectonic Map of Texas. John embraced the department's transition to digital illustration, and enjoyed learning new software and tinkering with computer hardware. In addition to creating maps, John was a skilled technical illustrator who worked with researchers to accurately illustrate their publications and presentations. One major undertaking was the drafting of 2009's *Chronostratigraphy of Cenozoic Depositional Sequences and Systems Tracts: A Wheeler Chart of the Northwest Margin of the Gulf of Mexico Basin*. John is an avid outdoorsman who enjoys scuba diving, sailing, hiking, camping, and photography.

Sigrid J. Clift, Public Information Geologist, retired in February 2013 after more than 24 years with the Bureau. At her standing-room-only retirement party, Associate Director Jay Kipper praised Sigrid for her outstanding work as a Research Scientist Associate. A prolific author, Sigrid was lead or secondary author of numerous journal articles, contract reports, and guidebooks, and of Reports of Investigations 211, 232, and 255.

In 1989, Sigrid began her career at the Bureau's Core Research Center, preparing and producing thin sections used in research projects. In 1991, Sigrid moved to the Bureau's main building, making maps and cross sections, doing petrographic analyses, and undertaking many other research tasks. Sigrid became the Bureau's Public Information Geologist in 1999, helping people with their questions about geology and other topics. Sigrid was also coordinator of the Petroleum Technology Transfer Council (PTTC) Texas Region and head of the Bureau's Resource Center (supervising the library, bookstore, and Geophysical Log Facility). Throughout her career, Sigrid participated in GeoFORCE and many other outreach events for students and the public, including organizing 12 annual Earth Science Week Career Days for middle-school students.

In 2008, Sigrid won the Jackson School's Outstanding Staff Award, and in 2011 she won the JSG Outstanding Service Award. Sigrid continues to be active in the Austin Geological Society, in which she heads the Publications Committee, and with the Bureau's STARR program.

Lana Dieterich, who retired in 2013, began her career at the Bureau as a proofreader in 1987, advancing to editor 2 years later. Her master's degree from UT in teaching English as a second language came in handy as the Bureau's research scope grew globally and the staff composition became more international. Lana edited major reports, atlases, maps, and papers, as well as maintaining detailed staff resumes, which were essential for supporting successful proposals for funding. She also mentored junior staff in the essentials of editing.

Known for her quick wit and sense of style—editorial and sartorial—Lana, in her parallel career, has been an award-winning actor in Austin theater for more than 30 years, achieving a place on the list of Austin's Top Forty Stage Actors (named by the *Austin Chronicle*). She has also appeared in films. For her many roles and accomplishments, we can only say, "Brava!"

Claudia Gerardo, departmental buyer, retired in August 2014 after 11 years with the Bureau. The only purchaser during much of her tenure, Claudia excelled at finding obscure and exotic equipment and at finding the best prices for purchases. Vendors and folks at the Bureau alike respected her for her forthright and honest, tough-as-nails negotiations. She was also expert at working within the University of Texas System and at expediting hurried requests. Claudia received her bachelor's and master's degrees in Foods and Nutrition through Human Ecology at Central Michigan University and excelled at preparing wonderful dishes and organizing food-related events at the Bureau. Her thesis project was "The Use of a Methocellulose Derivative as a Fat Substitute in a Baked Product." (She tested her theory with brownies.) She continues to give back to her community by participating in arts-related and homeowner's association volunteer work.

Kitty Milliken retired as a Senior Research Scientist in January 2015 after working at The University of Texas for most of the last 40 years. Kitty started at UT in the fall of 1975, where she served as a Teaching Assistant in the Department of Geological Sciences while completing her master's degree. Her first stint at the Bureau was in 1979–1980, when she joined a team investigating diagenesis and reservoir quality of Tertiary Gulf Coast sandstones and their significance to geopressured geothermal production. Kitty completed her Ph.D. at the Department in 1985 and worked there, except for two short stints elsewhere, until 2008, conducting research on diagenesis of a wide range of siliciclastic sediments and the evolution of rock properties in the subsurface, while also running the microbeam and XRD facilities. In 2008, Kitty returned to the Bureau, where her research focused on the application of electron microbeam imaging and analysis to interpret chemical and mechanical histories of mudrocks (oil and gas shales).

During her career, Kitty has authored and co-authored more than 80 peer-reviewed papers and has prepared award-winning digital resources for teaching sandstone and carbonate petrography. As a Lecturer in the Department, she taught mainly graduate courses, particularly Siliciclastic Petrology. She served as Associate Editor of the *Journal of Sedimentary Research* (1993–2000) and as Co-Editor (2004–2008). In 2006, she toured as a Distinguished Lecturer for the AAPG. Kitty will begin her retirement with a flourish: she is the 2015 recipient of both the AAPG Robert R. Berg Outstanding Research Award and the Wallace E. Pratt Memorial Award for the best *AAPG Bulletin* article published in 2013.

Seay Nance retired in December 2014 after serving 37 years at the Bureau. He began his Bureau career in 1977, processing core in the Core Research Center, which at that time was known as the Well Sample Library. Seay went on to supervise both the Sedimentation Laboratory and the Thin-Section Laboratory before moving into research in 1983. His research projects include West Texas Waste Isolation, Reservoir Characterization Research Laboratory, Superconducting Super Collider, Coalbed Methane, Permian Basin Geological Synthesis, and Mudrock Systems Research Laboratory. Seay's expertise is broad: stratigraphy, sedimentology, geomorphology, structural geology, hydrogeology, and geochemistry. He also has deep experience in both subsurface and outcrop studies. Seay is author or co-author of over 60 publications and had made over 70 oral presentations. Seay has been a lifelong student, earning three degrees in geology from The University of Texas at Austin spread across 30 years; he completed his Ph.D. in 2010. To the Bureau family, Seay has been a dependable friend, a go-to guy, a mentor, and a gadfly.

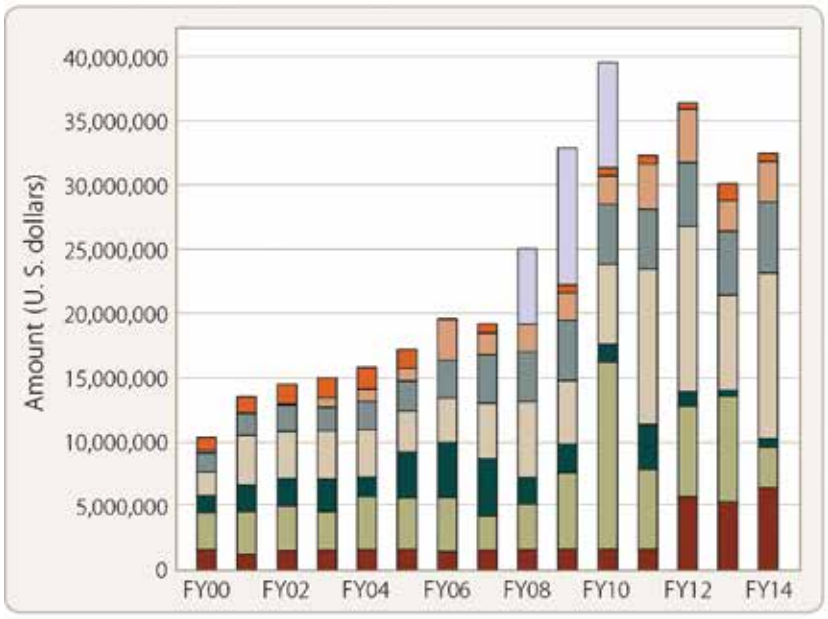
Fred Wang retired in June 2014 after 23 years at the Bureau. Fred, who received his Ph.D. in Petroleum Engineering from Stanford University in 1986, joined the Bureau as a Research Fellow in 1991; he was promoted to Research Associate in 1992 and to Research Scientist in 2001. As a member of the Reservoir Characterization Research Laboratory (RCRL), Fred was an important part of a team effort researching improved methods for constructing realistic carbonate reservoir models. His primary focus was developing new methods for integrating geologic and petrophysical data into the construction of flow models. The reservoir projects he was involved in include several giant West Texas fields such as Seminole, Hobbs, and Fullerton. In addition, Fred made significant advances in modeling carbonate reservoirs using outcrop data from the Guadalupe Mountains. In later years, Fred used his engineering talents to optimize production from the giant East Texas Field and to understand production from the Haynesville and Barnett gas shale plays. He was a member of the team that received the prestigious Wallace E. Pratt Memorial Award from the AAPG in 2011 for their work on the East Texas Field.

Lesli Wood, Senior Research Scientist, departed the Bureau in December 2014 for the Colorado School of Mines, where she is a full professor and holds the prestigious Robert J. Weimer Endowed Chair in Petroleum Geology. In 2005, Lesli founded the Bureau's Quantitative Clastics Laboratory (QCL) Industrial Associates Program; by 2014, sponsorship had grown to 16 companies. (In her absence, QCL will continue as one of the 10 Industrial Associates programs at the Bureau.) Lesli also holds leadership roles in several national and regional professional organizations and has won numerous national awards for presentations, papers, and posters.

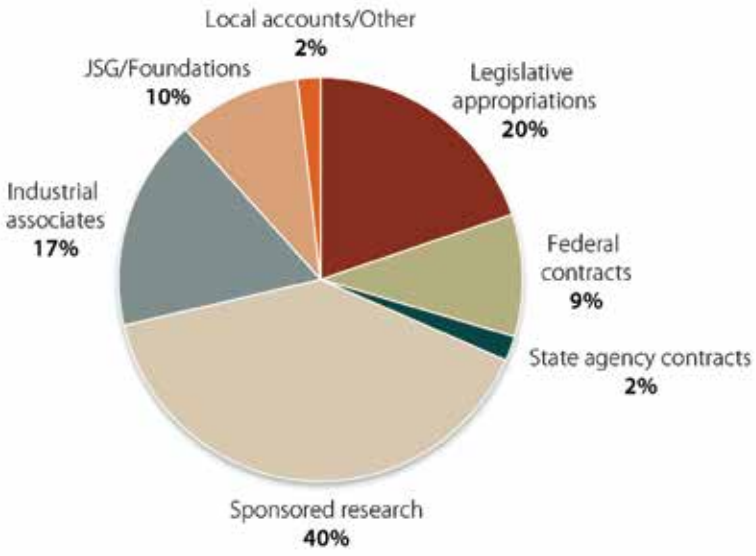
Lesli's remarkable 17-year run at the Bureau was fueled by her seemingly unlimited energy and enthusiasm. Though she once remarked, "I do not claim to know what I am talking about," she does indeed know what she's talking about and, as supervisor to perhaps more graduate students than anyone else in the Jackson School over the past decade, has shared her research interests in clastic sedimentology, sequence stratigraphy, and seismic geomorphology.

Finances

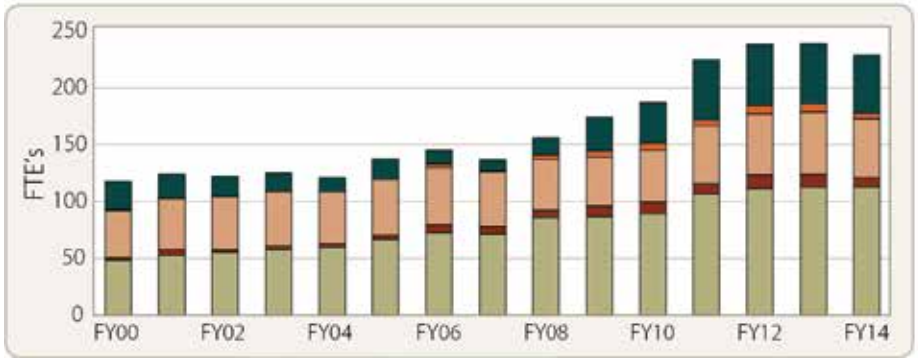
Grants, Contracts, and Other Revenue



Fiscal Year 2014



Fulltime-Equivalent Staff



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