

2011

Annual Report

Bureau of Economic Geology



BUREAU OF ECONOMIC GEOLOGY
SCOTT W. TINKER, DIRECTOR

QAe932

Director's Message

I know it's not Texan of me to admit, but I don't watch a lot of football on TV. I enjoy the game, but it's a matter of having the time. However, recently we watched Super Bowl XLVI. Tom Brady played quarterback for the New England Patriots. Several weeks earlier I had mentioned Brady in my State of the Bureau address, in the context of competition. While playing at my alma mater, the University of Michigan, Tom had to battle every week with a younger—more “gifted”—Drew Henson for the starting position. Brady credits that intense individual competition with his drive toward excellence and, ultimately, his success as one of the NFL's premier quarterbacks of all time.

Competition arises whenever two parties or more strive for a goal that cannot be shared. Competition is hardly limited to sport. Examples abound in music (Beethoven influenced by Mozart), art (Matisse and Picasso; Michelangelo in the shadow of a seasoned Leonardo da Vinci), photography (*Sports Illustrated* photographer Walter Iooss competing weekly with Neil Leifer for the magazine's cover), business (Bill Gates and Larry Ellison), science (Thomas Edison and Nikola Tesla), and nations (USA and USSR racing to the moon). Competition drives us to strive—to reach deeper and be better than we would have been otherwise. Of course there is a fine line between healthy competition and obsession. Think Tonya Harding and Nancy Kerrigan. Did Salieri really poison Mozart? And consider perhaps the world's greatest living athlete, Michael Jordan, who could not relinquish the memory of not making the varsity high school basketball team as a sophomore and who carried animosity toward his coach, “Pop” Herring, all the way to his acceptance speech during induction into the NBA Hall of Fame in 2009. Let it go, Michael...

Instead of competition, in academe we focus more on collegiality and collaboration—when groups work together to realize goals by sharing knowledge and learning and by building consensus. Examples of healthy collaboration within the Bureau include the several Industrial Associates programs, in which many companies support a common research theme; the Advanced Energy Consortium, in which 10 major companies support “precompetitive” research at 25 global universities; and the Gulf Coast Carbon Center, in which more than 20 national labs, universities, and private-sector companies work together, with federal support, on carbon sequestration.

Although discussion of competition in the halls of academe is muted, competition is nonetheless real. At the Bureau we compete for funding, talent, and publications. Competition for external funding keeps us sharp and relevant; competition for talented people keeps us healthy and diverse; competition for publications keeps us current and fine tuned. Competition is not something to shy away from but, instead, in context, to embrace. Without competition, the world might never have known *The Last Supper*, *David*, *Requiem*, electricity, “The Shot,” Microsoft, or the world-class organization that is the Bureau of Economic Geology.

At the Bureau, we walk the competition-collaboration line. *Competition* drives us toward excellence, and excellence allows us to *collaborate* with the very best in the world. A powerful combination.



Scott W. Tinker

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Bureau Highlights

Shell–Bureau Partnership Forged

On September 13, Shell and The University of Texas at Austin signed a 5-year agreement to invest \$7.5 million to address short- and long-term challenges facing the growing worldwide unconventional oil and gas industry. The Bureau, a leader in unconventional resources research, will manage the new Shell-UT Program on Unconventional Resources with participation across the campus, including geoscience, engineering, economics, business, environmental, and regulatory affairs. “This agreement marks an important milestone in Shell’s commitment to continually research and develop innovative technology that will help to meet global demands by bringing more energy resources to market,” said Shell President Marvin Odum. “We chose to collaborate with UT because it brings



together an extraordinary amount of talent from both organizations that will push the technological envelope in the field of developing even the most challenging hydrocarbons safely and responsibly.” Bureau Director **Scott Tinker** thinks that the program will have a far-reaching impact. “Increased production of shale gas and other unconventional hydrocar-

bons could significantly enhance U.S. energy security,” Tinker said, “since these are largely available, affordable, and reliable domestic energy sources that contribute directly to the U.S. and global economy.” For more information, read the press release at <http://www.beg.utexas.edu/docs/Shell-UT%20collaboration.pdf>. See story on Unconventionals on p. 9.

Pardon Our Dust

Major renovations began on the Bureau’s lobby and first-floor hallways on December 12. The new lobby will feature an updated work station for receptionists, a renovated publication-sales store, new paint and tile, and many other changes. Visitors may find the construction disorienting, but be assured that Bureau staff will be nearby to assist you in finding, for example, Bureau publication sales, which is temporarily moving to the reading room adjacent to the main lobby. All publication-sales services will remain unchanged during renovations.





Bureau Celebrates Statoil and Shell Partnerships

On September 20, the Bureau Contracts & Grants staff and the Office of Industry Engagement (OIE) gathered for a luncheon in celebration of the recent signing of three complex, wide-reaching research agreements funded through Statoil ASA and Shell International Exploration and Production Inc. Associate Directors **Eric Potter** and **Michael Young**



spoke briefly about the role and activities of the Bureau in Energy and Environment, and **Bridget Scanlon** described her research in water quality and availability. **Joseph El-Azzi** spoke on his groundbreaking lidar-imaging techniques and internet-accessible platforms.



Bureau Goes Green

The Bureau now features one of two new solar-panel arrays on UT-Austin's PRC campus. Online since mid-June, the Bureau array was placed on top of a newly constructed carport on the building's west side. The project was funded by an 80% matching grant as part of a federal stimulus program to encourage development of renewable energy sources. The array



is able to generate 27,000 kilowatt-hours of electricity each year, supplying up to 6% of the Bureau's energy requirements. Not only will the system provide long-term energy savings, it will also reduce the annual discharge of carbon into the atmosphere by more than 6 metric tons. For more, see *Austin American-Statesman* story at <http://www.statesman.com/news/local/ut-pickle-campus-solar-power-system-billed-as-1515490.html>.



New Bureau Consortium Meets

Fifty-eight people, including representatives from eleven companies (BGP, BP, Chevron, ConocoPhillips, ExxonMobil, Fusion Petroleum, Hess, PGS, Shell, Total, and Zterra) attended the inaugural meeting of the Texas Consortium for



Computational Seismology on March 17 and 18 at BEG's Houston Research Center. The newly formed consortium is a cooperative effort of BEG and UT's Institute for Computational Engineering and Sciences (ICES). According to Co-PI and co-founder **Sergey Fomel**, the consortium's mission is to address the most important and challenging research problems in computational geophysics facing the energy industry today while educating the next generation of research geophysicists and computational scientists. Bureau scientists making presentations at the

meeting included **Karl Scheicher**, a senior research fellow, and five Ph.D. students: **William Burnett**, **Vladimir Bashkardin**, **Parvaneh Karimi**, **Siwei Li**, and **Xiaolei Song**.



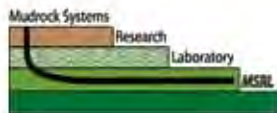
Welcome, ExxonMobil!

On Friday, April 1st, the Bureau hosted a group of ExxonMobil geologists and engineers, all participants in a week-long company internship program in unconventional resources. The group attended a morning of lectures at the Bureau, which were related to research areas of the ongoing ExxonMobil/Bureau of Economic Geology Unconventional Reservoirs Research project. The afternoon was devoted to a core workshop on gas shale and fractured tight gas sandstones, as well as tours of the

laboratory facilities at the Bureau's Core Research Center. ExxonMobil hosted a dinner

on Friday night, and Bureau researchers **Kitty Milliken** and **Tongwei Zhang** accompanied the group on their field trip to the Barnett Shale quarry in San Saba on Saturday. The 2nd Biannual Research meeting was held in Austin, September 26 and 27. Representatives from member companies and institutions viewed more than 20 presentations focused on seismic data processing, wave propagation, and fast algorithms and inverse problems. In addition to presiding over the conference, **Sergey Fomel** presented "Local Slope as a Universal Attribute."

Mudrock Consortium Meeting Well Attended



The 2011 meeting of the Mudrock Systems Research Laboratory was

held March 9–10 at the Commons building on the J. J. Pickle Campus. More than 100 industry geologists representing 25 member companies attended the meeting, which included a workshop, 24 oral presentations and 15 core and poster presentations. Presenters included 19 Bureau researchers (**Steve Ruppel PI**, **Bob Loucks**, **Ursula Hammes**, **Robert Baumgardner**, **Ray Eastwood**, **Greg Frébourg**, **Scott Hamlin**, **Ryan Harbor**, **Tucker Hentz**, **David Hull**, **Farzam Javadpour**, **Kitty Milliken**, **Seay Nance**, **Chris Ogiesoba**, **Ryan Phelps**, **Eric Potter**, **Rob Reed**, **Fred Wang**, and **Tongwei Zhang**) as well as Harry Rowe (and 8 students from UT Arlington) and Dan Jarvie (Worldwide Geochemistry). **Sammy Jacobo**, **Nate Ivicic**, **Kenneth Edwards**, and **Cathy Brown** also played key roles in the success of the meeting, handling all organization and logistic issues.

CEE Marches on

On March 17, **Dr. Michelle Michot Foss** gave testimony at the Committee



on Natural Resources oversight hearing on “Harnessing American Resources to Create Jobs and Address Rising Gasoline Prices: Domestic Resources and Economic Impacts.” The hearings focused on rapidly escalating gasoline prices and ways that harnessing

energy resources on Federal lands might reduce energy costs while helping to create new jobs. From July 11 through 14, CEE led a training program on oil value chain economics for Uganda energy-sector directors and professionals in Kampala, Uganda. Dr. Foss and **Dr. Gürcan Gülen** served as facilitators and instructors for the event, which was sponsored by the U.S. Department of State-Energy Governance and Capacity Initiative and U.S. Agency for International Development. Dr. Foss was invited to join the Technical Advisory Group for Natural Resource Charter, led by Paul Collier, Oxford University, and chaired by former president of Mexico, Dr. Ernesto Zedillo, and she attended the annual Charter Conference June 29–30. From May 31 through June 3, CEE hosted a group of 23 mid-level executives from Sinopec (China) in Houston. The program is a 21-week-long Leadership Executive Education program developed for Sinopec E&P by UT’s McCombs School of Business Executive Education. While

in Houston, the group attended presentations by CEE-UT senior staff and visited Houston-

based oil-field service companies. During the last week of July, Dr. Foss taught a course in Austin titled “Global Challenges and Future Outlooks” to the group. Dr. Gülen taught a course titled “Energy Economics” to the group later in the summer.



AEC en Masse in Massachusetts and at the Bureau

The Advanced Energy Consortium (AEC) conducted its first biannual all projects review meeting of the year June 1–3 at Schlumberger’s Doll Research Center (DRC) in Cambridge, Massachusetts. The mission of the AEC is to promote transformational understanding of the flow of oil and gas in the subsurface reservoir, and the consortium-funded research continues to mature. A voluminous number of new and relevant data were presented, and for the first time the agenda included presentations from project Co-PI’s, providing additional depth and perspective. More than 150 registered participants attended, including members of the Board of Managers (BoM), Technical Advisory Council (TAC), member-company mentors, collaborating principal investigators, and their students. From December 6 through 8, more than 125 participants attended the second biannual 3-day meeting right here at the Bureau. It combined a workshop in contrast agents, an AEC board meeting, and a full complement of project reviews.

Bureau Scientist GSA Special Paper Co-Editor



Bureau Research Scientist **Bill Ambrose** and David Williams from Arizona State University are co-editors of GSA Special

Paper 477 “Recent Advances and Current Research Issues in Lunar Stratigraphy.” The volume features a

variety of articles on stratigraphy of lunar mare basalts, recently recognized large-impact basins, including South-Pole Aitken and Schrödinger, and lunar volcanogenic terrains.

Milliken First Author of Important Educational DVD

Bureau Scientist **Kitty Milliken** and coauthor Suk-Joo Choh completed a major educational resource, *Carbonate Petrology v. 1.0: An Interactive Petrography Tutorial: AAPG Discovery Series No. 15*, which was years in the making. It's a DVD, hyperlinked

and interactive throughout, the main content focusing on 82 high-resolution scans of entire thin sections. Each section is zoomable and mapped with mouse-over annotations. The DVD includes a glossary of carbonate

petrology terms, a tutorial on classification, a tutorial on all the major fossil allochems, plus five more on ooids, intraclasts, pellets and peloids, cements, and pores. One section is on petrographic methods (from hand lens through light microscopy to SE, BSE, CL, and X-ray mapping). Other sections deal with stains and peels and thin-section flaws, not to mention the all-important "guide for instructors."



EGL Meets

The Exploration Geophysics Laboratory (EGL) convened its 2011 Annual



Sponsors Meeting at the Bureau on April 19. Representatives from the consortium's more than 20 industry and government partners saw presentations on topics ranging from elastic wavefield seismic stratigraphy to geothermal energy. Among Bureau presenters were **Bob Hardage**, **Michael DeAngelo**, and **Donald Wagoner**.

PTTC and Bureau Join Forces for STARR Workshop

On Wednesday and Thursday, June 22 and 23, STARR researchers showcased their latest research on Haynesville and



Bossier shale-gas formation and produc-

tion. Over the course of the 2-day workshop, **Ursula Hammes**, **Gregory Frébourg**, **Bob Loucks**, and **Fred Wang** enlightened 25 students and 40 industry participants on the sedimentology, stratigraphy, and mudrock pore studies of the region, while utilizing the Bureau's Austin Core Research Center for hands-on demonstrations of the area's geology. The workshop was part of an ongoing series aimed at oil and gas professionals and students by the Bureau in conjunction with the Petroleum Technology Transfer Council. Students were sponsored by the Gulf Coast Section of SEPM. The Bureau's **Robert Newsham** coordinated the 2-day event.

AGL Meeting Has Record Attendance

A record 355 people from 31 companies attended the 2011 Applied Geodynamics Laboratory meeting held in Austin November 3, 4. Delegates heard presentations on salt structures that ranged from microscopic to basin scales. Bureau scientists **Tim Dooley**, **Mike Hudec**, **Martin Jackson**, **Gang Luo**, and **Maria Nikolinakou**



all authored talks presented at the meeting. **Amanda Masterson** of the Bureau bookstore took advantage of the occasion to sell more than 170 copies of AGL's new book, *The Salt Mine: a Digital Atlas of Salt Tectonics*. Meeting logistics were ably handled by **Nancy Cottingham** and **Sammy Jacobo**.



Bureau Attends Geothermal Energy Utilization Conference

The Bureau partnered with Southern Methodist University and corporate sponsors to present the 2011 Geothermal Energy Utilization Conference on the SMU campus



in Dallas, June 13–15. The 3-day conference brought together research

leaders from business and academe to discuss specific issues relevant to expanding geothermal electrical production in oil and gas fields. **Bruce Cutright** of BEG's STARR group presented "Transformation of Tight Shale Gas Formations to Geothermal Energy Production," a talk exploring the possibilities of substantially enhancing long-term energy resources by transitioning existing shale fields to geothermal energy production. The conference explored these opportunities and discussed ready technologies that can make geothermal energy production economically competitive with wind, solar energy, and biofuels.

MSRL Missions

The Bureau's Mudrock Systems Research Laboratory (MSRL) scientists have been conducting extensive field studies on the Cenomanian-Turonian Boquillas Formation, an outcropping analog of the "hot" Eagle Ford Shale. **Steve Ruppel, Bob Loucks, David Smith, and Gregory Frébourg** have been on multiple missions to Uvalde and Terrell Counties, where

roadcuts along U.S. 90 display good-quality and laterally extensive exposures of the Boquillas Formation.



GCCC Biannual Meeting

On July 14, the Gulf Coast Carbon Center (GCCC) convened its biannual sponsor's meeting at the Bureau's Houston Research Center, with special focus on an active summer for the group and its partners. **PI Susan Hovorka** welcomed attendees with a review of GCCC's current research plan and a look forward through 2014, conducting a session on "Technology Intersection with Policy" and an update on the SECARB program as well. **Sigrid Clift** spoke on GCCC's evolving outreach and provided an overview of the group's ambitious public-education programs. Bureau researchers also presented their latest work: **Alex Sun** spoke on "Above-Zone Groundwater Monitoring," **Seyyed Hosseini** spoke on "Reservoir Characterization and Modeling Perspective," and **Vanessa Nuñez** presented "Novel Modeling Approach for the Monitoring of CCS Sites." **Tip Meckel** presented an update on the Offshore Carbon Repository, including completed groundwork and planned research for the next 6 months, and



Katherine Romanak presented "New Soil-Gas and Groundwater Methods."

Bureau Hosts Visiting Committee

On August 5, **Scott Tinker** called to order the annual meeting of the BEG Visiting Committee. The morning began with an introduction of the committee's newest member, the Honorable Barry Smitherman, who was recently appointed by Governor Rick Perry to serve as a commissioner on the Railroad Commission of Texas. The morning agenda continued with an informative discussion of the Bureau's strategic planning process, with great feedback from committee members. The afternoon focused on a preview of the two professional society meetings that the Bureau is hosting in 2012 (GCAGS and AASG), followed by a detailed analysis of ideas for the expansion of the Bureau STARR program.



(left to right): Jay Kipper, BEG; Robert Mace, TWDB; Kevin Ward, Trinity River Authority; Mark Vickery, TCEQ; Bud Scherr, Valence Operating; Barry Smitherman, RRC; Jerry Patterson, GLO; Michael Ming, the State of Oklahoma; Scott Tinker, BEG; Tim Brittan, Infinity Oil & Gas; Bud Brigham, Brigham Exploration; Chuck Williamson, Consultant; Michael Young, BEG; Eric Potter, BEG; Bill Ambrose, BEG.

Hardage et al. SEG Book Published

Four authors from BEG's Exploration Geophysics Lab—Bob Hardage, Mike DeAngelo, Paul Murray, and Diana Sava—collaborated on the new book *Multicomponent Seismic Technology*, published by the Society of Exploration Geophysicists.

This book brings multicomponent seismic technology up to the present. Practical

application of multicomponent seismic technology is emphasized, with chapters dedicated to data-acquisition procedures, data-processing strategies, techniques for depth registering P and S data, rock-physics principles, joint interpretations of P and S data, and numerous case histories that demonstrate the value of multicomponent data for evaluating onshore and offshore prospects.

All forms of multicomponent seismic data are considered—3C, 4C, and 9C. Interpretation focuses on elastic-wavefield seismic stratigraphy, in which a seismic interpreter gives the same weight to S-wave data as to P-wave data when defining seismic sequences and seismic facies. S-wave splitting in fractured media and other key theoretical concepts are supported by numerous data examples.



Meckel at Next Generation Project in Fort Worth

On October 21, **Tip Meckel** joined 50 young leaders from around Texas to participate as a sponsored fellow at the Next Generation Project: Texas Assembly (<http://strausscenter.org/nextgen/about-nextgen.html>) in Fort Worth. The project was begun in 2005 by the American Assembly of Columbia University (founded by Dwight Eisenhower in 1950), and the meeting was convened by the Strauss Center for International Security and Law at The University of Texas at Austin. Goals of the Texas Assembly are to foster cutting-edge, innovative solutions to our shared global challenges by gathering the best and brightest young business and academic leaders

from around the state to discuss issues through rigorous, responsible debate. The meeting focused on energy, economic development, the environment, and U.S. global policy. NGP Fellows are sponsored by veteran Texas oilman Jon Brumley, who was honored earlier in October as a Distinguished Alumnus of UT.

RCRL Core Workshop and Meeting

On October 9, 73 industry representatives from 23 companies attended the Reservoir Characterization Research Laboratory (RCRL) core workshop, which was followed by 2 days of technical presentations on RCRL's latest research results. A dinner at the Zilker Clubhouse Monday evening was highlighted by a spectacular fall sunset and perfect weather.

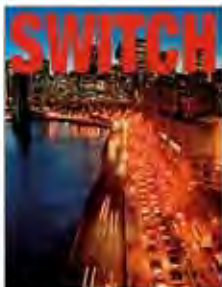


Bureau Folks in the News

Director **Scott Tinker** was interviewed in the summer by ABB, a technology-based provider of power and automation products, regarding the global oil and gas energy scene. In this interview, Scott discussed the evolution of technological advances, their impact on the accessibility of reserves, and the importance of access to energy reserves for companies to stay competitive. The trend from conventional to unconventional was highlighted, with a focus on infrastructure and natural gas. Scott talked about the technological challenges in the extraction of unconventional oil and gas and some of the advances that are changing the face of the oil and gas industry. Also discussed was the importance of industrial and individual energy efficiency, notably the impact of effective "broad incentives that encourage industries and individuals to become more efficient." Scott replied to questions about carbon capture and sequestration and the implications of cost on the viability of this new, innovative process. Read the full interview at http://www.beg.utexas.edu/Tinker/media/14-19%202m142_ENG_72dpi.pdf.

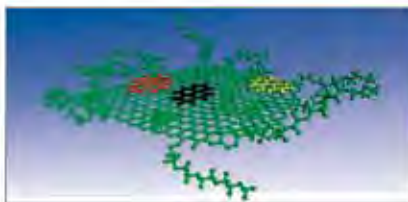
► On October 17 and 18, Austin audiences filled theatres on the UT campus and at the Alamo Draffhouse to catch advance screenings of *Switch*, a documentary film that delves into the economic and geopolitical implications of the world's search for practical alternative-energy sources. Directed

by award-winning filmmaker Harry Lynch, the film follows Bureau Director **Scott Tinker** around the world as he takes a comprehensive



look at global energy supply, demand, scale, and infrastructure. The focus is on energy resources that are likely to be dominant in the coming century, and energy efficiency figures prominently in all demand sectors, especially transportation, heating, and power. The screenings were followed by enthusiastic question-and-answer sessions. The film is part of a larger educational initiative that will include K-12 outreach and resources to provide accurate information about the world's energy choices and help create a culture of energy education in schools.

► "Connecting R&D with the Goals of E&P," an article recently published in the *Journal of Petroleum Technology*, highlights a recent keynote address by Bureau Director **Scott Tinker** at the SPE 2011 Research & Development Symposium in Austin. In his talk, Scott described creation of the Advanced Energy Consortium (AEC) and its definitive goal of placing nanotech-



nology applications in the field within 10 years. The article discusses this and other cutting-edge research now being undertaken for improved energy exploration and discovery. To read the full article, go to <http://www.beg.utexas.edu/Tinker/media/R&D-AEC-JPT.pdf>.

► The cameras were rolling at Blanton Auditorium on the University of Texas at Austin campus as Director **Scott Tinker** presented "The Future of Energy" on March 30. The talk was filmed as part of an ongoing 2-year documentary project about the challenges of meeting the world's rapidly increasing energy needs with both conventional and alternative energy sources. The documentary, *Switch*, was discussed earlier in this section and will soon be featured on a large website. Tinker's talk and documentary were also part of the March 31st edition of the *Daily Texan*.

► Bureau scientist **Bob Hardage** was interviewed by the *Oil & Gas Journal* in a piece titled "Point of View: Multicomponent Seismic Work Seen at Crossroads." Bob, current president of the Society of Exploration Geophysicists, sat down with Bob Tippee, editor of the journal, for the interview.

"We are at this crossroads because a few accepted the technology too fast, did poor implementation, and discouraged others," Bob is quoted as saying. But as the head of the BEG Exploration Geophysics Laboratory, Bob goes on to say that "we are making progress." To read the whole interview, which covers setbacks and breakthroughs, sign in at <http://www.ogj.com/articles/print/volume-109/issue-36/general-interest/special-report-applied-geophysics/point-of-view-multicomponent-seismic-work.html>.





► **Geology** published "Deep-Water Erosional Remnants in Eastern Offshore Trinidad as Terrestrial Analogs for Teardrop-Shaped Islands on Mars: Implications for Outflow Channel Formation" by **Lorena Moscardelli** and **Lesli Wood** in its July edition. The paper was published online May 24 and is currently available to subscribers of *Geology*. In this paper, the authors proposed that teardrop-shaped islands located in the circum-Chryse Planitia region

on Mars were formed by erosion as part of a series of subaqueous mass wasting events. The authors used a deep-water terrestrial analog located in eastern offshore Trinidad to highlight similarities between the Martian and terrestrial features. A better understanding of flow conditions within the outflow channels of Mars could help

unravel aspects of their origin and feasibility of the existence of a standing body of water in the northern plains of Mars. This paper was also featured in the June 21 edition of *Wired Science: News for Your Neurons* on the internet. In the article, "Streamlined Islands Could Mean Ancient Oceans on Mars" by Lisa Grossman, Lorena talks about her underwater work in Trinidad and is quoted as saying "Most analogies between Earth and Mars are made using continental (on-land) data sets or environments because that data is easier to gather. I am providing for the first time, as far as I know, a deep-water terrestrial analog." For the whole story, see http://www.wired.com/wiredscience/2011/06/teardrop-shaped-island/?utm_source=feedburner&utm_medium=feed&utm_campaign=Feed%3A+ Wired+Science%29.

► **Farzam Javadpour** and the Advanced Energy Consortium were featured in the September 2011 issue of *GEO Expro*. The petroleum geoscience magazine highlighted Javadpour's research in nanotechnology applications for shale reservoirs and enhanced recovery in the feature story "Mighty Thoughts of Small: Nanotechnology for Upstream Applications." To read the full article, go to <http://www.beg.utexas.edu/docs/Geoexpro%20vol%208%20no%204%20nanotech.pdf>.

► **Hongliu Zeng, Bob Loucks, Xavier Janson**, et al. produced an image worthy of gracing the cover of the December *AAPG Bulletin*. The abstract of their paper, "Three-Dimensional Seismic Geomorphology and Analysis of the Ordovician



Paleokarst Drainage System in the Central Tabei Uplift, Northern Tarim Basin, Western China," says "High-quality

three-dimensional seismic data acquired in the central Tabei Uplift, Tarim Basin, western China, provide a rare opportunity to characterize in exceptional detail the three-dimensional geomorphology of a deeply buried (5500–6500 m [18,045–21,325 ft]) Ordovician unconformity and the related paleokarst drainage system." The image is a three-dimensional relief map of a time-structure map on top of a karstified Ordovician section.

Bureau Scientists on YouTube

Katherine Romanak and **Brad Wolaver** have a big on-screen



presence in the half-hour YouTube video on a study that they conducted in Canada. Dealing with the controversial CO₂ injection near an oil field, the study found that the CO₂ discovered on the Kerr farm near Regina, Saskatchewan, was naturally occurring. To see the two stars in action, go to <http://www.youtube.com/watch?v=wcxIXpl211Q&context=C20924ADOEgsToPDskKWX2eABkFNHfA4JLauAFv7>.

A story about the findings also appeared in the Regina Leader-Post at <http://www.leaderpost.com/technology/contamination+found+Kerr+farm+IPAC+report+says/5847235/story.html>. **Changbing Yang** participated in the study as well.

Energy Research Focus:

Unconventional Oil and Gas Resources

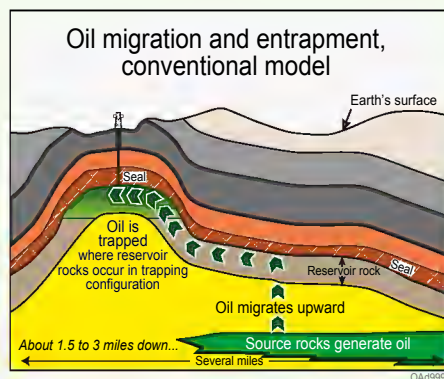
Why distinguish between conventional and unconventional?

For 150 years, exploration for hydrocarbons was focused on finding oil and gas that had migrated from a source rock to a subsurface trap. The understanding that hydrocarbons migrate distances of miles laterally and thousands of feet vertically has driven exploration strategies and tool development. The resulting enterprise was essentially a hunt. The quarry was oil and gas in porous rock layers at dead-ends of migration flow paths, otherwise known as *traps*. Trap types include anticlines, stratigraphic pinch-outs, and other geometries that block upward and lateral migration of hydrocarbons.

After many decades of exploration success, targets became more difficult to find. Today's exploration in ultradeep waters offshore and in other hostile environments—both logistical and political—is testament to the difficulties in finding large conventional oil and gas fields today.

The hunt for conventional oil depended on three key conditions—migrated hydrocarbons, good-quality reservoir rocks, and a tight cap rock or “seal.” During development of a discovered field, the presence of porous and permeable reservoir rocks meant that one well, with little if any stimulation, could drain a large volume of oil or gas from the field. Furthermore, when production from the field declined and production became uneconomic, additional strategies were possible. Waterflooding involves pumping saltwater into selected wells and using it to move some of the remaining oil to producing wells. After waterflooding,

enhanced recovery techniques using carbon dioxide, surfactants, or steam floods typically result in production of additional reserves from an aging field. Such techniques would not be feasible in the absence of good porosity and permeability in reservoir rocks, however.



Transition to unconventional

In the 1960's and 1970's, a new class of resource was recognized that would later be tagged *unconventional*. Initial forays into this new class involved tight-gas sandstones, which were thick, widespread, and gas bearing but which typically had permeabilities that were so low that gas would not flow into the well bore unless the formation was stimulated in some way. The stimulation method of choice became the hydraulic-fracture treatment. Water, sand, and chemical additives were pumped into the pay zone of these tight-sand wells, causing the rock to fracture. By the late 1980's, tens of thousands of vertical wells had been hydraulically fractured in tight-gas-sand targets in the Rocky Mountain, Appalachian, Permian, and East Texas Basins. Tight-gas sands thus became the first major unconventional resource success. The keys to success

were identifying and mapping the resource and employing hydraulic fracturing to unlock the gas from the low-permeability rock. Exploration companies were no longer hunting for migrated hydrocarbons. Instead they were gathering oil and gas that was still in or near the original source rock.

Hydraulic fracturing is essentially a method of creating permeability pathways where none existed previously. The water's role is to convey pressure to the target rock formation, causing it to fracture over a period of a few hours. The sand's role is to pack the new fractures, preventing them from closing after the frac job ends. The chemical additives' main roles in frac jobs are to

- ▶ increase the rate at which water can be pumped down the limited-diameter well bore;
- ▶ control viscosity of the frac fluid (mostly water), enabling it to transport sand farther into the new fractures; and
- ▶ prevent the growth of bacteria that could clog flow paths in the formation.

The shale revolution begins elsewhere but matures in Texas

Shales, or *mudrocks*, were long neglected as targets for exploration or subjects for research. However, a small community of geochemists, petrographers, and sedimentologists studied organic-rich shales throughout the 20th century because these shales were known to be source rocks for oil and gas. Because of the importance of source rocks in oil



From Devon Energy, 2006

exploration, formations known to be rich in organic carbon—typically black mudstones—had been widely mapped in the U.S. subsurface by the 1960's. Examples include the Bakken, Mowry, and Phosphoria Shales in the Rocky Mountains; the Marcellus and Utica Shales of the Appalachian Basin; the Floyd Shale in the Black Warrior Basin; and the Barnett, Eagle Ford, Haynesville, and Bossier Shales of Texas.

All of these formations had been the source of natural gas and/or oil from

exploration wells that targeted other, more porous formations. But the shale production volumes were generally low, and high decline rates were almost universal. These signs pointed to limited production potential, with flow most likely occurring from naturally fractured intervals in the shales. Sporadic production occurred in many basins, and thousands of relatively low rate wells were drilled in the Antrim Shale of the Michigan Basin, the Ohio Shale of the Appalachian Basin, and the New Albany Shale of the Illinois Basin.

The game changer for shales was exploration in the 1980's and 1990's by Mitchell Energy in the Barnett Shale of

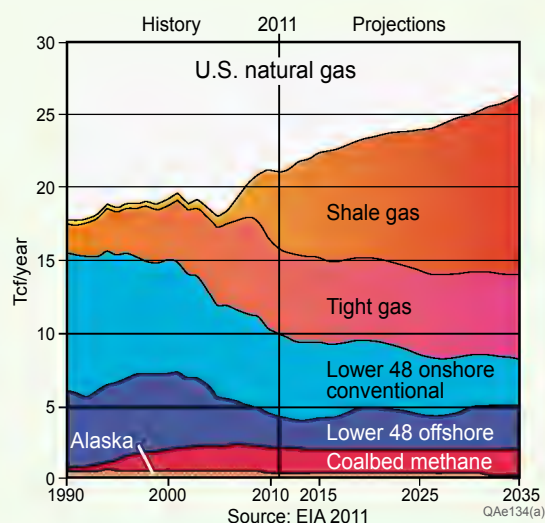
the Fort Worth Basin, Texas. Methodical, multiwell drilling and hydraulic fracturing ("fracking") experiments were conducted by Mitchell, which proved to be frustrating as well as tantalizing. By the late 1990's, Mitchell's persistence began to pay off, with dozens of commercially successful fracked vertical wells. As the price of natural gas improved in the period from 2000 through 2008, many other companies studied Mitchell's success and came to recognize the large potential reserves and profitability of shale gas in the Barnett. When the early players in the Barnett began drilling horizontal wells and conducting multistage frac programs along the horizontal well bores, the shale revolution had begun.

Global resource impact of shale gas and oil?

Gas production from the Barnett and other shales already exceeds 16 billion cubic feet (Bcf) per day, or approximately 28% of daily U.S. gas production. With further expansion of shale plays, daily gas production from shale could increase to nearly 40% of U.S. demand by 2035, according to the U.S. Energy Information Administration.

However, the potential resource impact from shale is not limited to gas. Three major plays—Bakken (North Dakota/Montana), Eagle Ford (South Texas), and Marcellus (Ohio, Pennsylvania)—are producing oil from shales or from tight, nonshale reservoir layers immediately adjacent to the shale. Daily oil production from the Bakken already exceeds that of the nation's largest conventional field, Prudhoe Bay in Alaska. The large aggregate production rates of gas and oil from shales were recognized by a few academic researchers but not anticipated by analysts 10 or 15 years ago. Most





knew that shales contained oil and gas but failed to realize that frac programs in horizontal shale wells could cause so much oil and gas to flow to the well bore. Now the central questions are: (1) how large is the producible reserve base and (2) under what economic and environmental conditions will it be attractive to produce?

Role of research

The success of tight-sand and shale plays has emboldened industry to drill tens of thousands of new wells and to plan for tens of thousands of additional wells. But exactly where and how these new wells will be drilled, and how well they will perform, are matters of some interest. Individual well results in both tight sands and shales vary dramatically within a given play, giving rise to the term *sweet spots* for the best areas. Even within the sweet spots of each play, poor wells are completed adjacent to good wells. Does this fact suggest that natural fractures or variable diagenesis determines well performance? Or did different drilling and completion techniques make some wells good and others poor? Are later-completed wells interfering with earlier completions? Where exactly are the oil and gas within these tight reservoirs, and how do the molecules move from there to the well bore? Can

key aspects of the reservoirs be imaged remotely using seismic technologies? Can innovative completion techniques improve recovery? How much oil and gas will ultimately be recovered from these unconventional targets? These are some of the questions that focus our research at the Bureau.

A significant Bureau research program targets unconventional resources, funded by industry, government, foundations, and NGO's

Starting in the 1970's, the Bureau invested in analyzing tight sands and coalbed methane, the two mainstays of unconventional resources predating the shale revolution. These projects were successful because they incorporated rock-based research, particularly in the study of natural fractures. An outgrowth of this early work was establishment of the Fracture Research and Application Consortium (FRAC). This group (sections on individual research components follow) pioneered the characterization of natural fractures in tight-gas sands and demonstrated the clear link between open natural fractures and production quality. More recent centers of excellence have been established in mudrock research, multicomponent seismic applications, and reservoir-quality aspects of ultradeep, tight sandstone prospects in the Gulf of Mexico (GOM). A unique state-funded program, the State of Texas Advanced Resource Recovery (STARR) program, conducts Texas-specific research, aiding operators in Texas in identification and production of more oil and gas from unconventional targets. Sponsored research programs with ExxonMobil, Shell, and ConocoPhillips are also under way. Research funded by a federal pass-through program called

Research Partnership to Secure Energy for America (RPSEA) has focused on several key questions in unconventional resources. All told, more than \$5 million per year is spent at the Bureau on research in unconventional hydrocarbon systems. New laboratory capabilities worth more than \$4 million are in place, and more than one-third of the Bureau's 100 researchers are involved in some aspect of this research. Many of these research programs are described briefly in the following sections.

Fracture Research and Applications Consortium (FRAC) and Unconventionals—

Steve Laubach, Jon Olson, Randy Marrett, Julia Gale, John Hooker, Sergey Fomel, Peter Eichhubl, John Holder, Rob Reed

The Fracture Research and Application Consortium (FRAC), currently funded by 13 companies and several grants from the Basic Energy Sciences Division of the Department of Energy, engages in fundamental and applied research toward the successful characterization, prediction, and simulation of naturally and artificially fractured reservoirs and the diagenesis that occurs during the process of rock deformation. Unconventional shale, tight-gas sandstone, tight carbonates, and structural diagenesis are topics of current research. A key arm of the program investigates mechanical and chemical fracture processes and interactions over a range of scales. The goal is improved prediction of the geometry, spatial distribution, and hydraulic properties of subseismic-scale structural heterogeneities and their influence on fluid migration, production, injection, and cementation. Predicting



the evolution of mechanical and fracture stratigraphy and explaining how rock properties and structures interact with hydraulic fractures are central parts of the program. The multidisciplinary FRAC team of research engineers and geoscientists is uniquely qualified to address these issues.

Fractures and faults have worldwide importance because of their influence on successful extraction of resources. Many faults and fractures are difficult or impossible to characterize adequately using currently available technology. Consequently, reservoirs that contain fractures have been intractable to effective description or interpretation, posing serious challenges for exploration, development, and accurate reservoir simulation and reservoir management. More accurate prediction and characterization of fractures hold great potential for improving production by increasing the success and efficiency of exploration and recovery processes. The aims of this program are 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 will lead to more realistic characterization of fractured and faulted reservoir rocks. These methods will produce data that can enhance well-test and seismic interpretations and that can be used readily in reservoir simulators.

FRAC's rock-based research utilizes cores and outcrops, and ideally both are used in a research project. Outcrops (see inset next page) provide insights about fracture spacing, clustering, azimuth, cement fill, and relationship to stratigraphy, although some outcrop fractures are artifacts of the natural exhumation process. Cores complement these outcrop observations and contain fractures that are more likely to represent those in the reservoir. Because cores sample such a small volume of rock, strategies are employed to leverage the insights obtained from microfractures, which are nearly always present.

FRAC has a major initiative under way to investigate fracture systems in shale-gas plays. Specific goals are to seek unifying principles that govern the development and properties of fractures in shale-gas plays, with the aim of improving systematic fracture prediction and characterization. Toward this end, FRAC will adopt the structural-diagenesis approach, making use of principles that have been shown to work in tight-gas sandstones and dolostones.

FRAC is building a comprehensive library of rock properties of shales, including fracture-mechanic properties collected using unique tests developed in the FRAC program. FRAC has developed software that uses these rock properties and other

information to predict natural-fracture spatial arrangement and to forecast permeability. A key component of FRAC research is development of software and test protocols that lead to accurate predictions of patterns of hydraulic fracture growth in fractured reservoirs. Scientists in the FRAC program were among the first to recognize this phenomenon, and the FRAC approach to multifracture growth is an industry benchmark.

Recently concluded studies include fracture characteristics of the New Albany and Marcellus Shales, and a new study is under way in the Monterey Shale of California.

Tight-gas sandstones have been an area of FRAC research since the inception of the program. This research is designed to create a robust, accurate, and testable procedure for predicting and verifying variations in porosity and permeability in deep, tight sandstones. A unique aspect is that rock-mass predictions will explicitly include effects of fractures by combining an innovative numerical model for predicting sandstone porosity and permeability, new models for predicting rock mechanical properties through time and space, and a successful computational model for predicting fracture-growth patterns. In deep, unconventional gas and oil plays, better predictions are key to locating and producing hydrocarbons economically. FRAC research provides new geologic system models and exploration concepts that will help workers find new and overlooked fairways for oil and gas production. Better interwell fracture characterization will also allow for improved reservoir management, leading to maximum economic recovery of hydrocarbon resources.

One part of this program, in collaboration with Sergey Fomel and his group, employs novel *seismic*

diffraction techniques in imaging fault and fracture systems that are below seismic resolution using conventional seismic techniques. Separating diffracted and reflected signals in seismic-reflection data and imaging diffractions separately allow zones of anomalous fracture intensity to be identified. In addition, multiazimuth analysis of diffraction focusing provides information on fracture orientation, as well as seismic velocity and anisotropy. These techniques are currently being



tested by modeling of synthetic seismic responses to outcrop-generated fault and fracture patterns obtained from field sites that share fundamental characteristics with producing subsurface reservoirs. In late 2011, FRAC tested these techniques using an industry seismic data set from the Piceance Basin, Colorado.

Seismic-diffraction imaging needs more case studies before it develops into a mature technology and is accepted by industry. Experience in analyzing such data through collaboration with industry partners is growing. Development of connections with fracture-analysis techniques from outcrop, core, and well log data is crucial, so that results of seismic analysis can be verified and calibrated.

Mudrock Systems Research Lab (MSRL)—

Steve Ruppel, Bob Loucks, Greg Frébourg, Uschi Hammes, Scott Hamlin, Seay Nance, Farzam Javadpour, Tongwei Zhang, Kitty Milliken, Rob Reed, Julia Gale, Fred Wang, Harry Rowe, Ray Eastwood, Cari Breton, Nick Hayman

The Mudrock Systems Research Lab (MSRL) program, currently funded by 24 companies, brings together a broad spectrum of research expertise necessary to confront the complicated, multidisciplinary questions that are key to a better understanding of mudrock systems. The goal is to integrate observations and data from all scales, ranging from nanoscale pores to regional basin setting, from element maps to borehole and 3D geophysics, and from clay diagenesis to sequence stratigraphy, in both outcrop and the subsurface. Only through this kind of integrated approach can the multiscale heterogeneities of mudrocks be effectively characterized and models leading to better predictions of reservoir quality developed.

The current explosion of interest in these rocks stems from their potential as oil and gas reservoirs. However, few of the approaches used for more conventional sandstone and carbonate hydrocarbon successions are applicable. The challenge is to develop new methodologies for characterizing these rocks. Much of this work must be carried out on high-precision, high-resolution instruments that are not commonly utilized in other sedimentary-rock systems. Key areas of research:

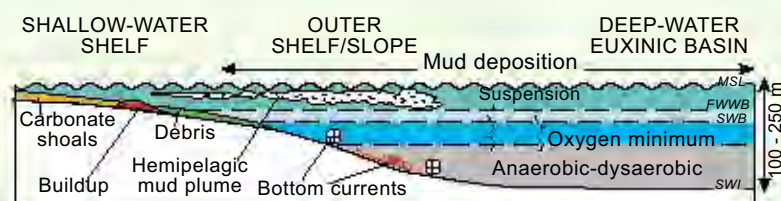
- Sedimentology: facies character and distribution
- Stratigraphy: regional, reservoir, and micro- and nanoscale architecture



- Diagenesis: clay and silica diagenesis, compaction, cementation, and fracturing
- Pore systems: imaging, size, abundance, distribution, and evolution
- Petrophysics: wireline-log calibration and upscaling
- Organic geochemistry: kerogen distribution, thermal maturity, and adsorption/desorption capacity
- Inorganic geochemistry: depositional and diagenetic controls on elemental composition
- Gas chemistry: origin, storage, distribution, and flow
- Fluid flow: modeling of nanoscale permeability
- Engineering: analysis of completion practices and their relation to rock attributes

Research methods and instrumentation:

- Nanopore analysis: field-emission scanning electron microscopy (SEM), Ar-ion milling, atomic-force microscopy (AFM)
- Elemental and mineralogical composition: field-emission SEM, cathodoluminescence (CL), X-ray mapping, and light micros-



copy; electron microprobe, XRD, XRF, stable-isotope analysis

- ▶ Fluid-flow modeling: AFM
- ▶ Organic-matter and hydrocarbon analysis: Rock Eval; gas chromatography (GC); gas chromatography mass spectrometry (GCMS); $\delta^{13}\text{C}$; saturates, aromatics, resins, and asphaltenes (SARA); vitrinite reflectance; and kerogen analysis
- ▶ Attribute distribution: integrated outcrop, core, and geophysical analysis, as well as X-ray CT
- ▶ Rock mechanics and fractures: integrated core study and basin-history modeling

Stratigraphic/Structural Architecture and Sandstone Reservoir Quality in Deep Shelf Gas Plays—

Shirley Dutton, Bob Loucks, Bill Ambrose, Cari Breton, Aaron Averett

The Deep Shelf Gas Program, currently funded by 18 companies, examines deep, hot reservoirs below the shallow waters of the present-day continental shelf. Wells targeting large structures below the shelf are being drilled to depths greater than 25,000 ft for sandstones deposited in lowstand systems tracts. At these depths, the greatest unknown and most critical risk factor is reservoir quality. The goal of the Deep Shelf Gas project is to decrease

exploration risk by (1) mapping the general structural and stratigraphic architecture and areas of deep to ultradeep depocenters and (2) providing concepts and empirical data that can be used to forecast reservoir quality at depth. The project also adds valuable regional knowledge to companies focused on down-dip deepwater GOM exploration.

The research is being conducted in 3-year phases. Phases 1 through 3 of the project examined deep to ultradeep Wilcox and younger Tertiary sandstone reservoirs along the Texas and Louisiana Gulf Coast. These deep Tertiary sandstones experienced extensive diagenesis, and their pore systems are dominated by secondary pores and micropores. Phase 4, now in progress, is focused on the Upper Cretaceous Tuscaloosa/Woodbine Formation below the shelf and in the deepwater GOM. Researchers have long recognized that chlorite coats preserve abnormally high porosity and permeability in onshore Tuscaloosa sandstones at depths greater than 18,000 ft by inhibiting quartz cementation.

The presence of this authigenic chlorite provides a reason for predicting that economic porosity and permeability could be preserved in Tuscaloosa sandstones at depths greater than 25,000 ft on the shelf or in the deepwater GOM. However, Tuscaloosa field studies have shown that thick, continuous, chlorite coats do not occur everywhere in the trend. Regional variation in Tuscaloosa sandstone composition, specifically the volume of detrital volcanic rock fragments (VRF's), may control regional variation in chlorite content because the chlorite is interpreted as being derived from alteration of VRF's. To improve reservoir-quality forecasting, Deep Shelf researchers

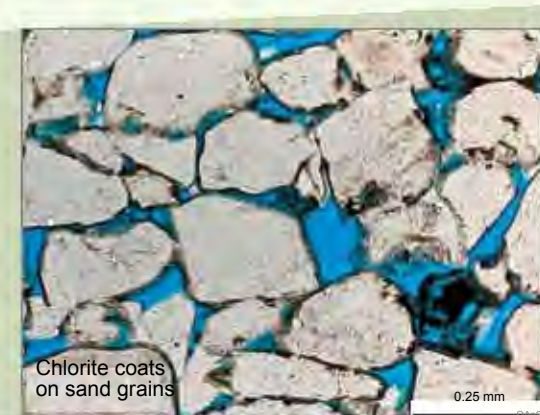
are conducting a comprehensive, regional study of trends in sandstone composition, diagenesis, and reservoir quality in Tuscaloosa/Woodbine sandstones. All cores from sampled wells are described so that depositional environment can be interpreted, and samples are placed into a sequence-stratigraphic systems tract framework. The 2-D seismic lines from ION-GX Technology GulfSPAN and LandSPAN surveys provide structural and stratigraphic context.

Exploration Geophysics Laboratory (EGL)—Multicomponent Seismic Evaluation of the Marcellus Shale and Associated Water-Storage Units—

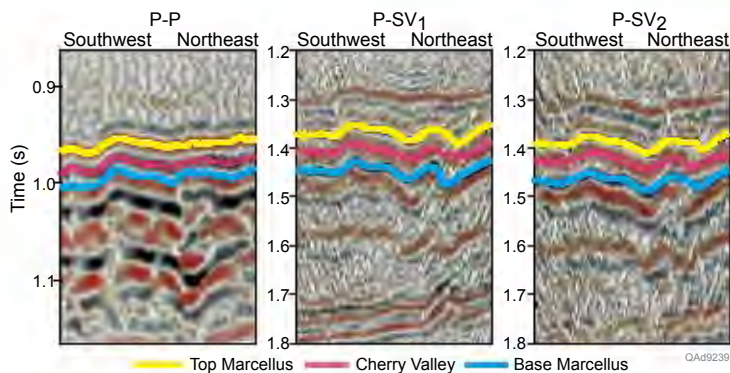
Bob Hardage, Diana Sava, Mike DeAngelo, Robert Graebner, Milo Backus, Don Wagner

The Exploration Geophysics Laboratory (EGL) has expanded its multicomponent seismic research to the Marcellus Shale and to porous-rock units local to the Marcellus that are candidates for storing flow-back waters from hydraulic fracturing operations. This research, which is funded by Research Partnership to Secure Energy for America (RPSEA), benefits from the contributions of six EGL scientists.

Objectives of the research are consistent with EGL's long-term research philosophy, which is to ask whether the combination of compressional (P) and shear (S) seismic data provides more information about geologic targets than does the traditional use of P-wave seismic data only. This Marcellus Shale research is developing compelling evidence to support the hypothesis that multicomponent seismic data are



Chlorite coats on sand grains



water. P-wave data show no evidence of intrareservoir heterogeneity. In contrast, P-SV data show a channel-like geobody that segregates the reservoir interval into separate compartments. The calibration well shown in the figure was drilled without the

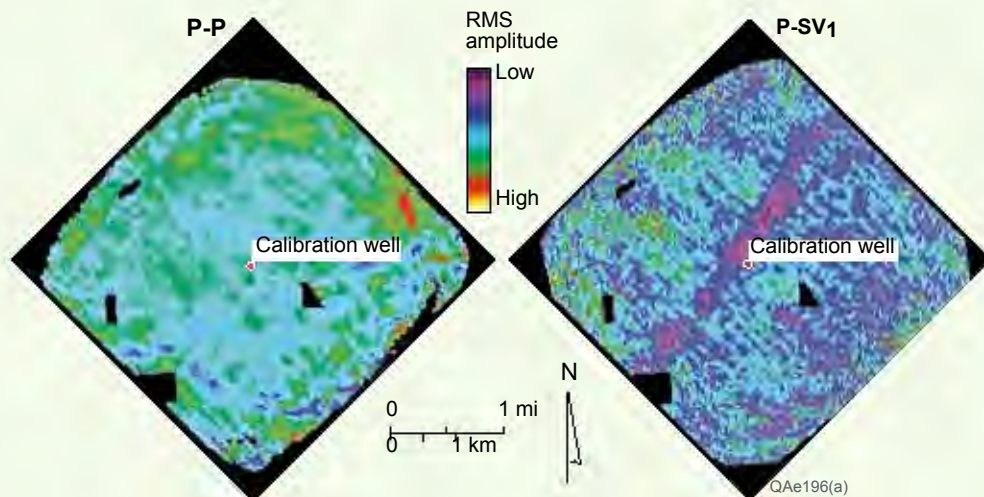
superior to single-component seismic data for optimal geologic analysis.

One example of the advantages of applying multicomponent seismic data to evaluation of the Marcellus Shale can be found in a comparison of P-wave and converted-S (P-SV) data spanning the Marcellus interval. Visual examination shows that not only is the spatial resolution of P-SV data better than that of P-wave data, but P-SV reflections are more continuous and provide improved definitions of vertical displacements. S-wave data thus provide important geologic information not expressed by P-wave data.

A second example can be found in map displays of P and P-SV reflection strength within a sand-prone Devonian interval that is considered a candidate for storing flow-back

availability of S-wave data and did not penetrate the channel-like feature. Subsurface control is therefore insufficient for us to determine whether this intrareservoir feature is geologic and, if so, whether it enhances or inhibits fluid flow. However, consideration of the presence of this feature is crucial to a consideration of this interval as a water-storage reservoir. Without S-wave imaging, presence of the heterogeneity would not be known.

The long-term objective of EGL is to expand multicomponent seismic research to other shale-gas plays to determine whether the principles established in the Appalachian Basin are unique to the higher-velocity rocks found in this basin or whether equivalent advantages of multicomponent seismic technology occur in all basins.



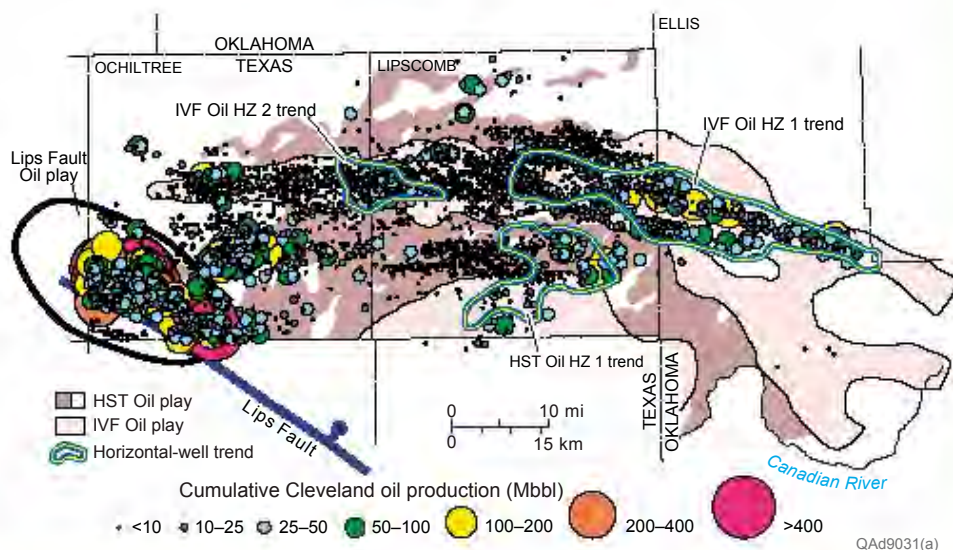
State of Texas Advanced Resource Recovery (STARR) program—

Bill Ambrose, Uschi Hammes, Tucker Hentz, Chris Ogiesoba, Scott Hamlin, Qilong Fu, Ned Frost, Laura Zahm, Cari Breton, David Smith

The STARR (State of Texas Advanced Resource Recovery) program investigates geologic controls on oil and gas production in tight (low-permeability) formations in the Texas Panhandle and west Texas. The goals of these regional projects, which include the Cleveland Formation and Marmaton Group in the west part of the Anadarko Basin and the Wolfberry Trend (Spraberry and Wolfcamp Formations) in the Midland Basin, are to (1) document the complex sandstone-body architecture and (2) investigate sequence-stratigraphic, facies, and structural controls on hydrocarbon productivity.

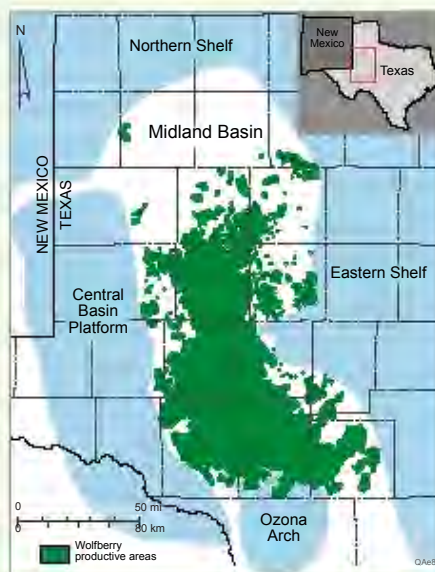
The Cleveland Formation has produced 1.1 trillion cubic feet (Tcf) of gas and 37.3 million barrels of oil (MMbbl) from tight sandstones in a play area that comprises Ochiltree and Lipscomb Counties, Texas, and adjacent Ellis County, Oklahoma. In addition, siliciclastics of the Marmaton Group have produced more than 14.0 Bcf and 1.5 MMbbl of oil from the two Texas counties. These producing intervals are part of a productive trend of tidally modified,

shallow-marine sandstones in the Anadarko Basin that encompasses the Texas Panhandle and western Oklahoma. Sandstones in the Cleveland Formation and Marmaton Group commonly require hydraulic fracturing and/or horizontal drilling to maximize permeability pathways and enhance productivity. Important issues that affect the success of these horizontal wells include



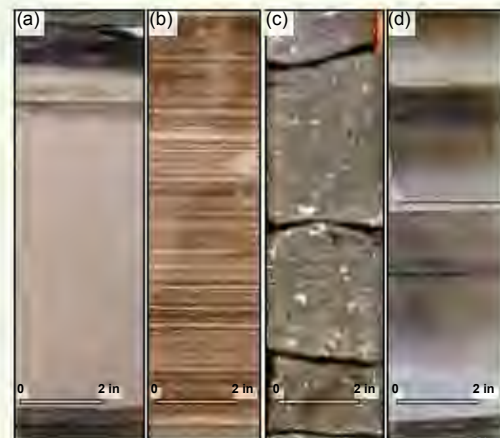
sandstone-body thickness, lateral continuity and geometry, and degree that interbedded siltstones reduce overall porosity and reservoir quality. The Cleveland-Marmaton STARR project, conducted in collaboration with Jones Energy, Ltd., used a data set consisting of 1,127 wells and 5 conventional cores with about 250 ft of section from the Cleveland Formation, as well as production data from both the Cleveland Formation and Marmaton Group from more than 900 wells. The study also included a play analysis of the Marmaton Group, which shares a depositional origin with the Cleveland Formation. The study has demonstrated the need to develop a robust sequence-stratigraphic and depositional-facies framework to explain controls on reservoir quality and continuity in these low-permeability formations. Results from this study were presented in an all-day workshop in Farmer's Branch, Texas, November 2009, and in the Bureau's Report of Investigations No. 275, which was released in September 2011 (see Bureau Publications, p. 34). The Permian (Leonardian) Spraberry and Dean sandstones have produced oil throughout

the Midland Basin since the late 1940's. Known as the Spraberry Trend, productive areas extend across 18 counties and contain more than 10 billion barrels (Bbbl) of oil in place. More recently, operators have been including deeper formations in their Spraberry Trend completions: first the Wolfcamp (Lower Permian), which underlies the Dean and deeper zones in the Pennsylvanian. This expanded productive interval is the Wolfberry play. Multiple hydraulic fracture stimulation stages open up these low-permeability formations to production over a 4,000-ft



vertical interval between 6,000 and 10,000 ft below land surface. Since the late 1990's, more than 8,700 Wolfberry oil wells have been completed and have produced 216 MMbbl of oil and 544 Bcf of gas. Initial well production averages 30 to 125 bopd, and ultimate per-well recovery is estimated at 100,000 to 140,000 bbl of oil equivalent. Wolfberry research at the Bureau is funded by STARR and MSRL projects. Bureau geologists are collaborating with several Wolfberry operators to achieve a better understanding of this complex hydrocarbon system.

The Wolfberry play is a resource play characterized by heterogeneous lithologies, low permeabilities, and reservoirs and source rocks in close proximity. The paleogeographic setting was a deep ocean basin surrounded by shallow carbonate platforms. Basin-floor stratigraphy comprises alternating layers of calcareous and siliciclastic lithofacies having widespread continuity. In siliciclastic intervals, such as the Spraberry and Dean, turbidite sandstones and laminated siltstones are interbedded with organic-rich mudrocks. In calcareous intervals, such as the lower Leonard and the Wolfcamp, carbonate debris flows are interbedded with carbonate turbidites and organic-rich calcareous mudrocks. Although coarser grained turbidites and debris flows are the obvious reservoirs, finer grained



calcareous facies are also productive after fracture stimulation.

Core-based studies are essential to recognition of productive and source-rock intervals in the Wolfberry play. The Bureau's Core Research Centers hold more than 300 cores from Wolfberry formations in the Midland Basin. The team is working with Wolfberry operators to (1) maximize the utility of Bureau legacy cores through facies-based petrophysical and compositional analysis and (2) develop a regional stratigraphic context to help guide exploration and development of the play.

Key accomplishments in 2011 included regional stratigraphy and lithofacies distribution, quantification of reservoir and source-rock attributes, and production statistics. The research team is currently preparing a report on the Wolfberry for Bureau publication, but additional work remains. Compositions and flow properties measured in core samples must be correlated to wireline-log responses and then mapped throughout the basin. A fundamental goal of this research is to provide a robust geologic context so as to reduce uncertainty and encourage development of the Wolfberry play.

Sloan Foundation Grant— Taking U.S. Gas Shales Seriously—

Scott Tinker, Svetlana Ikonnikova, John Browning, Susan Horvath, Eric Potter, Ian Duncan, Gürçan Gülen, Bill Fisher, Forrest Roberts, Qilong Fu, Tad Patzek (PGE), Frank Male (PGE), Ken Medlock III (Rice)

The first year of this current 2-year study of the top five shale-gas plays has been addressing the question: What is the capacity of shale gas to contribute significantly to natural gas supply in the U.S. for the next 20 years? More specifically, can shale gas provide the volumes needed to meet future supply and mitigate price volatility?

Production data from the plays is being examined, with attention to variation in productivity within each play. Reasons for these variations in productivity are being explored so as to improve forecasting of future performance. Factors such as spatial distribution of high-producing zones and their geological characteristics, length of horizontal wells and number of frac stages, improvement of completion technology over time, and other factors, such as liquid content, are being examined. First, publicly available production data were examined in the more mature plays (Barnett, Fayetteville, and Haynesville). In the second year, the Marcellus and Eagle Ford will be

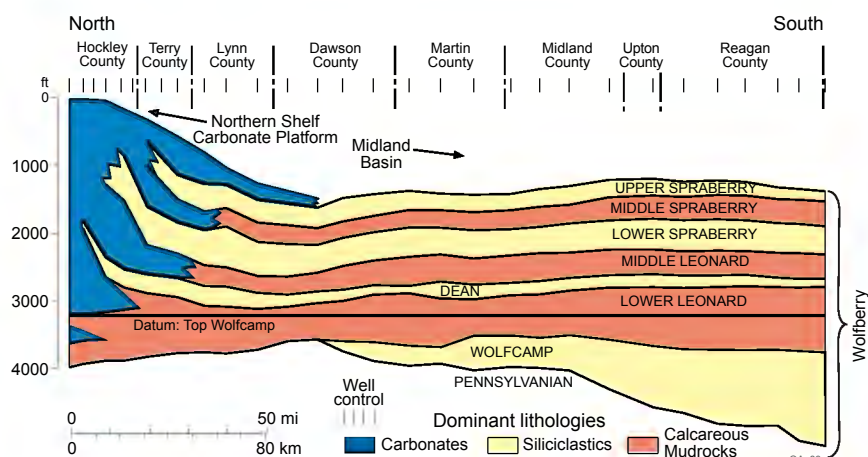
examined, which will have more wells and more production data by then. Timing is complicated in plays such as the Eagle Ford, in which operators have moved to liquid-rich areas, and less drilling is occurring in natural gas areas.

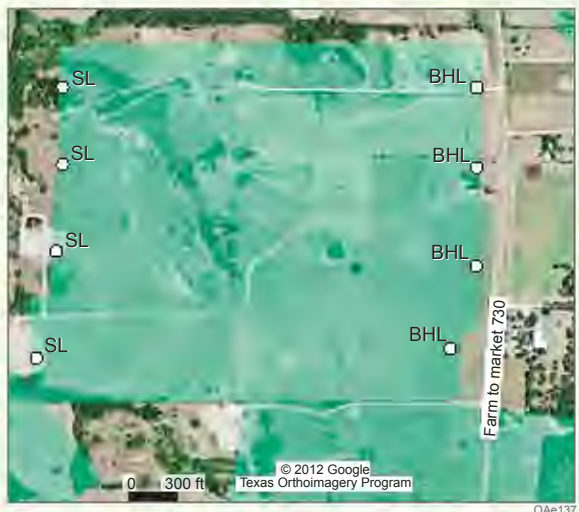
With the help of engineering and geological expertise and economic insights from these dominant U.S. shale-gas plays, the aggregate production and reserve potential in a 2- to 20-year time frame are being addressed. This study benefits from examination of every producing well in each basin. Resource and production capacities of these leading shale plays at different gas prices will be determined, and these scenarios will be translated into impact on the numbers of wells, rigs, frac jobs, water disposal, etc. required to meet various development scenarios. Detailed spacing and recompletion studies are part of the program, as is a rigorous economic analysis.

The figure on the following page shows a map of four horizontal wells in the Barnett play with interpreted drainage areas and a production graph for the same well group showing apparent interference when newer wells are brought on production.

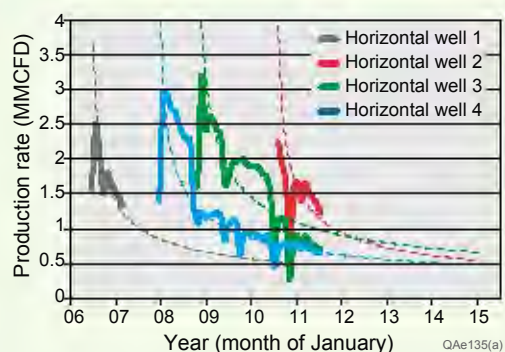
Below-ground understanding of major drivers as a foundation for sound investigations of above-ground regulatory and policy implications is addressed. This approach is combined with economic and commercial analysis and ultimately will help in modeling scenarios for future U.S. shale-gas production to predict pace of drilling activity levels required to meet various gas plateaus.

Private studies of this type exist, although results are often proprietary. The objective of the study is to dis-





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seminate better data and analysis to the public, where they can be utilized for policy and commercial decisions, including decisions by power-generating companies.

Water Use in Unconventional Oil and Gas Development in Texas—

J.-P. Nicot, Brad Wolaver, Yun Huang, Ruth Costley, Bridget Scanlon

The large increase in oil and gas production from tight sands and shales has generated environmental concerns because of the large number of wells needed to extract hydrocarbons from a resource play. Such an increase creates the potential for surface-water and shallow-groundwater contamination and could generate conflicts with other water users and stakeholders because of the large amount of water required to frac a well.

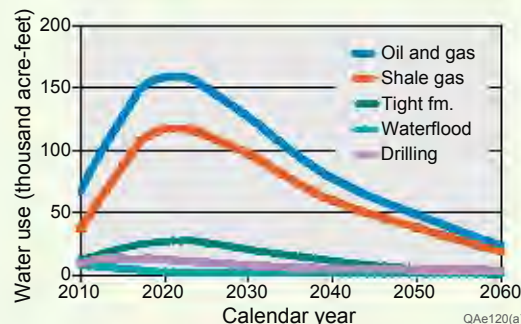
A recent study sponsored by the Texas Water Development Board, the state agency in charge of water planning, and led by the Bureau's J.-P. Nicot has determined that the amount of water used by the industry is smaller than that used by other industrial or municipal water users, although it nonetheless creates issues at the local scale, particularly in times of drought. As the massive, slick-water, hydraulic-fracturing technique expands to plays beyond the Barnett Shale, peak water use in the state might be three times current water use. At the same time, the state population is growing, and other water uses will also increase, straining all sources.

To limit conflicts, the State, cities, and the industry are interested in developing water resources that have been somewhat neglected

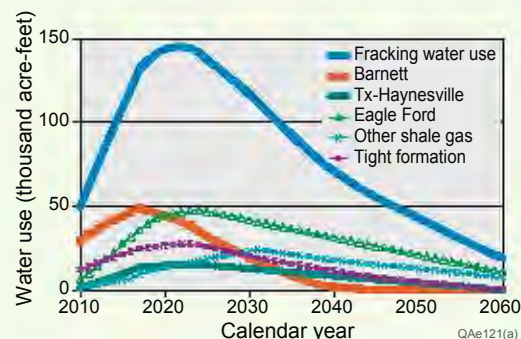
so far: brackish and other underutilized water resources. The Bureau has been collaborating with the Gas Technology Institute (GTI) to work on a project funded by RPSEA to better explain little-used aquifers in the footprint of the Barnett Shale. The project, led by J.-P. Nicot with the support of Bureau researchers Brad Wolaver, Yun Huang, and Ruth Costley, has concluded that there is potential in using local Paleozoic aquifers.

Another project, involving the same group of researchers and also funded by RPSEA but in collaboration with Houston Advanced Research Center (HARC), has started investigating the brackish-water resources overlying the Eagle Ford Shale play of South Texas. Ultimately the research group, broadened

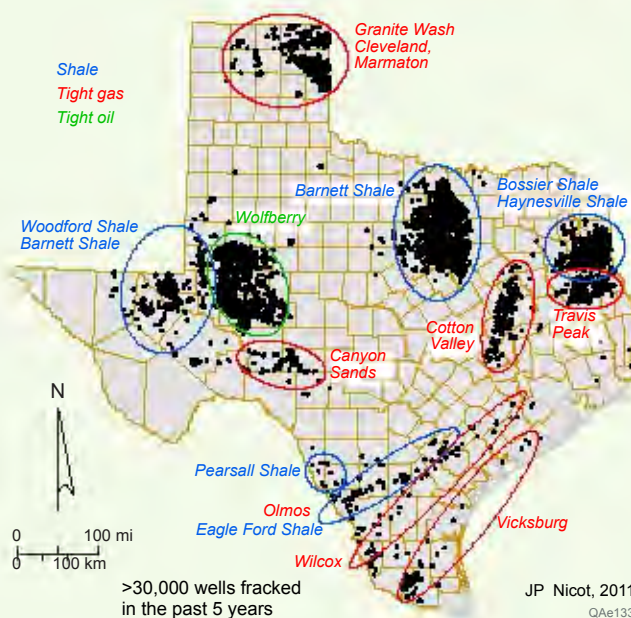
to include other researchers interested in shallow subsurface processes (Bridget Scanlon, Bob Reedy, Katherine Romanak, and Becky Smith), endeavors to explore the brackish-water resources of the state and how the industry can make use of them in a way that would benefit growing local communities in water-scarce areas, whose only long-term water option is ground-water desalination.



QAe120(a)



QAe121(a)



>30,000 wells fracked in the past 5 years

JP Nicot, 2011
QAe133

BEG

around the World

Tinker Travel

A few highlights from the Director's travel follow.

On January 13, Director **Scott Tinker** traveled to Greater Noida, India,



just outside Delhi, to speak at GeoIndia. His keynote address was titled "The Role of Shale Gas in the U.S. Energy Future: Global Implications." Closer to

home in early February, Scott participated in the inaugural McCombs School of Business Energy Forum on "Energy Resources in 20 Years." On March 1, Scott presented the keynote address at the Texas Independent Producers and Royalty Owners Association (TIPRO) 65th Annual Convention in Austin, which was titled "Global Energy Outlook." On March 9, he participated as an invited luncheon speaker at the Colorado School of Mines CoRE Lecture Series in Golden, Colorado. Scott spoke on "Energy: Powering the Future." He also participated in the Jackson School of Geosciences annual Latin American Forum in Colombia later in March, presenting a keynote address during the opening events. On April 26, Scott traveled to Chicago to participate in DOE's Quadrennial Technology Review (QTR) Alternative Fuels Workshop, hosted by Dr. Steven E. Koonin, U.S. Under Secretary for Science. This workshop was one in a series tasked by the President's Council of Advisors on Science and Technology in November 2010 with improving long-term planning and effectiveness of the United States energy policy implemented by the U.S. Department of Energy. Detailed information about the workshop can

be found online at http://energy.gov/sites/prod/files/FuelsPortfolio_0.pdf. On April 20, Scott participated in The Academy of Medicine, Engineering and Science of Texas (TAMEST's) Texas Energy Summit in College Station, Texas. Scott spoke on renewable energy options in the Electrical Power Generation session. Other participants at the event included Michael Ming, Oklahoma Secretary of Energy; the Honorable Bill Flores of the U.S. Congress; and Barry Smitherman, Chairman of the Public Utility Commission of Texas. Opening remarks were made by Senator Kay Bailey Hutchinson of Texas and by 2011 TAMEST President Stephen Holditch.

Scanlon in China

On October 21, **Bridget Scanlon** presented a keynote address on "Monitoring Groundwater Depletion Using GRACE Satellites in Irrigated Areas" at an International Symposium on Environmental Changes and Efficient Use of Agricultural Resources sponsored by the Chinese Academy of Sciences and the National Natural Science Foundation of China. Bridget is also collaborating with researchers and students in Shijiazhuang and Beijing on water resource

issues in the North China Plain and in the Hexi Corridor in NW China.

Hardage in China

On November 8, **Bob Hardage**, in his capacity as President of the Society of Exploration Geophysicists (SEG), gave a talk at the 4-day SPG/

SEG International Geophysical Conference in Shenzhen, China. SPG is the Society of Petroleum Geophysicists, a large professional society of Chinese

geophysicists. Bob also gave two invited technical talks at the conference, "Direct Shear Waves from Vertical-Force Sources" and "P-Wave and S-Wave Backscatter Noise across Surface Exposed High-Velocity Rocks." Bob says that his attendance at this international conference was a step in the process toward creating a new Chinese section of the SEG.

RCRL in China

Researchers from the Carbonate Reservoir Research Characterization Laboratory (RCRL) visited three major oil companies in China during the week of February 21. A series of lectures on carbonate pore networks, reservoir modeling, and seismic interpretation were presented to PetroChina in Hangzhou, Sinopec in Chengdu, and BGP in Zhuozhou by **Xavier Janson, Chris Zahm, Hongliu Zeng, and Bob Loucks**. The RCRL group hopes the visit leads to joint research opportunities with these companies. In the photo (next page), from left to right: Mr. Si (Vice President, PetroChina),





Chris Zahm, Hongliu Zeng, Mr. Xiong (President, PetroChina), Bob Loucks, Xavier Janson, Mr. Shen (Carbonate Group Manager, PetroChina), Mr. Zhang (Director of Science and Technology, PetroChina), and Ms. Wei (Director of Foreign Relations, PetroChina).

AEC Visits the Netherlands

Advanced Energy Consortium (AEC) members from Shell and Schlumberger recently visited TNO, a not-for-profit organization in the Netherlands that focuses on applied science. The AEC is funding a research project with TNO

that is developing quantum dot-based nanotechnology sensors. Qdots exhibit a bright photoluminescence that

is highly dependent on the type and size (<10 nanometers) of the particles, as well as their physical and chemical environment. Qdots are attractive candidates for nanoscale oil-reservoir sensors because they are inexpensive, nontoxic, environmentally friendly, and detectable at extremely low concentrations.



RCRL in Wyoming and Montana

This year's field trip to Wyoming and Montana, which was attended by 40 geoscientists, reviewed RCRL research on Mississippian evaporite paleokarst, sedimentology, and associated fracture development. The field trip was led by **Chris Zahm, Charles Kerans, Joseph El-Azzi, and Nabil Eldam**, as well as



Mark Sonnenfeld (Whiting) and Dave Katz (Chevron). Participants visited several large canyons with spectacular exposure of the Mississippian, such as Big Horn, Wind River, and Fremont Canyons and Guernsey Reservoir.

Hentz to Oklahoma



On May 10 **Tucker Hentz** presented an invited luncheon talk to the Tulsa Geological Society titled "Sequence

Stratigraphy, Depositional Settings, and Production Trends of the Middle and Upper Pennsylvanian Cleveland and Marmaton Tight-Gas Sandstones, Northwest Anadarko Basin," which was coauthored by **Bill Ambrose**. More than 100 people attended, which is testimony to the current interest in the active Cleveland and Marmaton plays in the Texas Panhandle and western Oklahoma. The presentation is a

summary of a STARR-funded project. Full details were published in BEG Report of Investigations No. 275 (p. 34).

Fomel Teaches Summer School in China and Russia

In China and Russia this summer, **Sergey Fomel** and his colleagues organized Schools on Reproducible Computational Geophysics using the Madagascar Software Package. The school in China was hosted by the Institute of Geology and Geophysics of the Chinese Academy of Sciences (CAS) and attracted 230 participants representing 12 Chinese universities, 5 companies, and CAS. The school in Russia was hosted by the Trofimuk Institute of Petroleum Geology and Geophysics (Siberian Branch of the Russian Academy of Sciences) and the Novosibirsk State University.



Utah Field Trip Led by Hudec

During the week of May 15–20, **Mike Hudec** led a field trip titled "Salt and Extensional Tectonics in the Paradox Basin, Utah," which 32 delegates from BP, Encana, Fugro, Nexen, Repsol, Samson, and Saudi Aramco attended. Topics in the field included the influence of salt in gravity-driven deformation, deformation

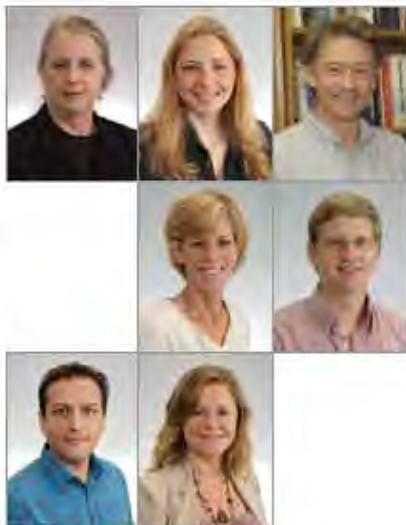




associated with salt-sheet emplacement, diapir pinch-off, extensional diapirism, and reservoir distribution around salt structures. Utah scenery and geology made up for the unseasonably cold, wet conditions.

GCCC—from Pittsburgh to Norway to Saskatchewan to Abu Dhabi

► Members of the Gulf Coast Carbon Center (GCCC) were present in force at the 10th Annual Conference on Carbon Capture and Sequestration in Pittsburgh, May 2–5. Those presenting talks and posters included **Susan Hovorka**, **Vanessa Nuñez-López**, **J.-P. Nicot**, **Katherine Romanak**, **Tip Meckel**, **Seyyed Hosseini**, and **Erin Miller**. More than 700 attended the annual conference sponsored by the Department of Energy's National Energy Technology Laboratory.



► On June 17 and 18, **Susan Hovorka** served on an eight-member scientific advisory committee at BIGCCS, a technology center in Jaegtovolden, Norway, with the goals of building expertise and closing critical knowledge gaps of the CO₂ chain, as well as developing novel technologies in extensive collaborative research. Earlier, at the Trondheim Carbon Capture and Storage Conference in



Trondheim (June 14–16), **Katherine Romanak** (above, left) presented “Soil-Gas identification of Vadose-Zone Carbon Cycling: Implications for Near Surface Monitoring at CCS Sites” and “Sensitivity of Shallow Groundwater Systems to CO₂: Case Studies from the Cranfield and SACROC EOR Fields” for **Changbing Yang**. Katherine also presented a poster titled “Natural CO₂ Releases Providing Messages for Stakeholders” with UK collaborator Tim Dixon (above, right) of the International Energy Agency Greenhouse Gas research program (IEAGHG). **Ian Duncan** also attended the conference and presented two posters.

► **Katherine Romanak**, **Brad Wolaver**, and **Changbing Yang** were members of a Bureau team that conducted research in March at the Kerr Farm, 100 miles southeast of Regina, Saskatchewan, Canada. The group is one of several international teams investigating claims by the Kerr family that CO₂ injection used for enhanced oil recovery has contaminated their land, killed wildlife, and polluted groundwater. As a leader in both groundwater and subsurface CO₂ injection, the Bureau was chosen to provide clarity to a complex problem.

“Our goal here is to reduce uncertainty as to the origin of the CO₂ on the Kerr property because there are allegations that the CO₂ is coming from the injection into the reservoir,” Romanak said. “But we also know that CO₂ occurs naturally in the near-surface environment. And it’s extremely variable,” she added. The Bureau team also used a different approach in its investigation: sampling soil gas at several depths to determine the concentrations of certain gases in relation to other gases. Romanak explained: “We’re using a method where we compare the concentration of co-existing gases and, by looking at these relationships, we can tell if it’s a naturally occurring signal or if it’s a signal produced by a leak.” Results of the Bureau research will be available in a December report to be issued by IPAC-CO₂, the Canadian-based research institute overseeing the project. To learn more, stories can be found in *Regina Leader-Post* and *Weyburn Review* newspapers at <http://www.leaderpost.com/Teams+search+farm+carbon+fingerprints/5337595/story.html> and <http://www.weyburnreview.com/article/20110907/WEYBURN0101/110909899/-1/weyburn/researchers-to-find-truth-on-kerr-farm>, respectively.

► On September 11, **Katherine Romanak** presented a talk in Abu Dhabi on groundwater protection at the United Nations Framework Convention on Climate Change Technical Workshop. The workshop made progress toward



allowing CCS projects under the Clean Development Mechanism (CDM) of the UNFCCC. Attending the workshop were 91 delegates from 33 countries and an array of experts. Presentations helped to inform the UNFCCC Secretariat, who is preparing options in a negotiating text for Parties in Durban later this fall.



Jackson Travels to Cardona and Calgary

► **Martin Jackson** of the Bureau's Applied Geodynamics Laboratory recently taught a short course on contractional salt tectonics for Maersk Oil in Cardona, Spain, and participated in field excursions in the Ebro foreland basin in the Pyrenean foothills that were led by Jaume Vergés. The group also visited exposures in the Cardona



salt mine, the frontal anticlines, and the footwall growth strata of Sant Llorenç de Morunys.

► Jackson later visited Condor Petroleum in Calgary to teach a short course on salt tectonics and consult on the Precaspian Basin in Kazakhstan. In the photo, Jaume Vergés (Group of Dynamics of the Lithosphere, Institute of Earth Sciences, Barcelona), Maura Sans (Ph.D., Department of Geodynamics and Geophysics, University of Barcelona), and Martin teach a workshop on compressional salt tectonics at Cardona Castle, Catalonia, sponsored and organized by Maersk Oil.



Hudec Heads South of the Border

► **Mike Hudec** visited Pemex's offices in Ciudad del Carmen, Mexico, April 11–15 to conduct a workshop on salt tectonics in the southern Gulf of Mexico. Participants reviewed seismic data from the area and developed

models for the tectonic evolution of the basin. Workshop participants (from left to right): Hector Lopez, Ulises Rodriguez, Mike, David Barrera, Juan Carlos Flores, and Rolando Peterson.



Moscardelli Visits Japan

► QCL's **Lorena Moscardelli** attended the 5th International Symposium on Submarine Mass Movements and Their Consequences in Kyoto, Japan. More than 300 scientists from around the world congregated in Kyoto to present their research covering a variety of subfields that included dynamics of submarine and subaerial landslide





dynamics, seafloor geomorphology and trigger mechanisms, postfailure dynamics, physical properties of sediments and slope stability assessment, mechanics of mass wasting in subduction margins, landslide-generated tsunamis, role of fluid flow in slope instability, and relevance of natural climate change in triggering slope failures. The conference was a great opportunity for an interchange of ideas and new developments in the area of submarine-landslide research. Lorena also attended the postconference field trip to Boso Peninsula in Central Japan, during which several outcrops containing spectacular mass-transport deposits and turbidites were visited. One outcrop, located in the Tateyama area, shows the contact between the upper Miocene to lower Pliocene Miura-Boso accretionary prism (Nishizaki and Ishido formations) and the Pliocene trench-slope-basin sediments of the Minami-Boso Group.

Dunlap in Milan

► On October 24, **Dallas Dunlap** presented a poster at the International AAPG Convention in Milan titled "Seismic Characteristics of Paleovolcanics Relative to Diapiric Salt in Rifted Basins," which details his investigation into differences between seismically imaged buried-salt and igneous structures. Trisha Dunlap photographed the trip.



► On October 12, **Michelle Michot Foss** of the Center for Economic Energy spoke at the 2011 Oil & Money Conference in London. Her presentation, "Energy Tradeoffs," was part of a panel on "The Future of Nuclear



Power and Renewables: Implications for Oil, Gas and Carbon Controls." Now in its 33rd year, the conference was

attended by more than 450 delegates from leading energy and finance sectors to assess likely future developments in global energy markets.



Public Outreach and Education

Laubach Continues AAPG Distinguished Lecture Tour

In September **Steve Laubach** completed the fall segment of his AAPG Distinguished Lecture tour. Venues ranged from ivy-covered walls of academic institutions in New England and Michigan to shady groves on the LSU campus in Baton Rouge. The title of Steve's talk is "Structural Diagenesis, Resource Plays, the Highlands of Scotland, and Curriculum Development." The spring segment of the tour will be in April, with visits planned in the western U.S.



Ichnology Short Course

In April, 25 attendees participated in a 2-day Ichnology Short Course at the Bureau. The course covered continental and marine trace fossils and was taught by Stephen Hasiotis (University of Kansas). Steve is an incredibly enthusiastic geologist who just returned from Antarctica, where he was working with the Bureau's **Peter Flaig**. Steve brought 50 pounds of rocks with him—teaching specimens for hands-on learning. The course, sponsored by the AAPG Student Chapter and the Jackson School of Geosciences, was coordinated by Ph.D. student **Dolores van der Kolk**.

Earth Science Week

Each year, a group of earth science professionals from the Austin area meet to plan activities for Earth Science Week (ESW) to educate students, teachers, and the general public about the earth sciences and to encourage stewardship of the Earth. The 12th annual Austin ESW career fair, held on October 7 at the Commons Learning Center, was organized by **Sigrid Cliff**, who was joined by a host of Bureau researchers and staff.



Approximately 250 middle school students and their teachers from the Austin area attended the event to learn about exciting careers in the earth sciences. More than 70 earth science professionals volunteered their time to participate as presenters, exhibitors, and tour guides. Thanks go out to the Bureau, Texas Space Grant Consortium, Lower Colorado River Authority, City of Austin Watershed Protection Department, Austin Geological Society, Anvil Energy, Border to Border Exploration, Subsurface Library, Commons Learning Center, American Geological Institute, Jackson School, and the volunteers for their financial and in-kind support that makes the career fair possible each year.

Explore UT

The University of Texas at Austin hosted 50,000+ attendees at its 2011 Explore UT open house. The Bureau's GCCC booth "What to Do with CO₂" explained the basics of carbon sequestration at the event, using models and demonstrations. GCCC staff **Susan Hovorka**, **Khandaker Zahid**, **Jiemin Lu**, **Katherine Romanak**, **Seyyed Hosseini**, **Vanessa Nuñez**, **Sigrid Cliff**, Carlos Puerta, Hilary Clement Olson, and Juli Berwald, as well as **Bridget Scanlon**, **Valentina Prigobbe**, **Melissa Garcia**, **Ursula Hammes**, **Reuben Reyes**, and **Sojan Mathew**, took turns entertaining and educating a steady stream of elementary, middle, and high school students and their parents throughout the day. The event was held on March 5.



Houston 5th Graders Visit Austin for Annual Field Trip

Fifth-grade students from Valley West Elementary in Houston came to Austin for their annual geology field trip on March 11. Topics for the day included (1) erosion, deposition,





sediment, lithification, rock types, and the law of superposition at McKinney Falls State Park; (2) earthquakes, faults, and displacement at Mount Bonnell; and (3) Deep Time in Texas Tour and Fabulous Fossils activity at the UT Texas Natural Science Center. **Sigrid Clift** was field-trip leader, and Dr. Pamela Owen led the tour and the fossil activity at the Texas Natural Science Center.

GeoFORCE/STORE/GCCC Teacher Workshop

As part of the Sequestration Training, Outreach, Research, and Education (STORE) Alliance, **Susan Hovorka** (in photo), **Katherine Romanak**, and Hilary Olson, as well as UTIG's Jon Olson, led a professional development workshop for GeoFORCE teachers titled "Energy and You: What to



Do with CO₂." GeoFORCE Texas is the nation's largest college-prep program for earth sciences. Almost 50 middle- and high-school teachers from south-west Texas and Houston attended the 2-day event, which covered the broad issue of our future energy mix, how fossil fuels fit into that mix, and how technological solutions, such as carbon capture and storage, play a role in the options for 21st-century, low-carbon footprint energy sources. The event was held in Austin.

TXESS Workshop

On June 13–25, GCCC's education and outreach partner STORE participated in a 2-week professional development workshop for middle- and high-school teachers in collaboration with the Texas Earth and Space Science (TXESS) Revolution program and the Texas Water Development Board. The workshop highlighted connections between energy, climate, and water for 25 teachers from all over Texas (and 1 from Jamaica). STORE provided expertise on several activities dealing with carbon capture and storage and a field trip to Luminant's Oak Grove



Power Plant and Kosse Mine. The event was held in the Austin area, and GCCC scientist **Becky Smyth** discussed the geochemistry of carbon dioxide with high school teachers attending the STORE/TXESS Revolution workshop.

Career Fair at UT DKR Memorial Stadium

The UT McCombs School of Business week-long Subiendo Academy for Rising Leaders is an annual 5-day intensive summer program that brings together aspiring high school seniors in Texas for an unforgettable leadership-development experience. Students have an opportunity to problem-solve real-world issues with today's top business and political names and work on projects in nontraditional classrooms and career settings. A career fair was organized for the academy that was held on June 15. **Sigrid Clift** represented the Bureau and the Jackson School and created a display titled "Policy and Geoscience." The students showed a great deal of interest in finding solutions to some of our most pressing problems, including energy, environment, and hazards.



Awards and Honors

Bureau Scientists Lead GeoFORCE Field Trips

Bureau researchers have traveled America from coast to coast this summer as teachers in the Jackson School's GeoFORCE program. **Tiffany Caudle** talked to 9th-grade students about coastal processes on the Florida coast; she later led students on a similar field trip to Port Aransas on the Texas coast. **Jeff Paine** toured the Pacific Northwest with 11th-grade students, and **Peter Flaig** taught 10th-grade students at the Grand Canyon while traversing Arizona, Utah, and Nevada. Other Bureau instructors included **Xavier Janson**, **Sigrid Cliff**, **Scott Rodgers**, and Associate Director **Eric Potter**. The GeoFORCE program provides South Texas and Houston-area high school students with the opportunity to travel and learn geology from expert geoscientists, as encouragement to consider attending college as a science or math major.

Bureau Seminar Series



In September AEC's **David Chapman** hosted the first of 13 presentations in the Bureau's Fall Seminar Series. UTIG's John

Snedden was the inaugural speaker in the series, which offers a wide range of topics presented by leading researchers from academe and industry. The list of future speakers includes Peter Malin of the University of Auckland, Alex Athey of UT's Applied Research Laboratories, John Ullo of Schlumberger, and **Martin Jackson**, **Bruce Cutright**, **Seay Nance**, **Lorena Moscardelli**, **Farzam Javadvpour**, **Vanessa Nuñez-Lopez**, **Zahra Mohammadi**, **Jiemin Lu**, and **Rebecca Smyth**, all Bureau scientists. Chapman is serving as coordinator and host of the fall series, now in its 13th

year, which is designed to increase awareness of current research and improve interdisciplinary collaboration. For a current listing of scheduled speakers, abstracts, and webcast links, go to http://www.beg.utexas.edu/presentations/sem_sched_F11.php.

PTTC Workshop

On June 16 and 17, the Petroleum Technology Transfer Council held a workshop at BEG's Houston Research Center on open software for reproducible computational geophysics. The event, organized by **Karl Schleicher** of the Texas Consortium of Computational Seismology (TCCS)



and **Robert Newsham**, centered largely on open-source Madagascar software. More than 40 attendees saw presentations by 15 presenters, including Schleicher and TCCS PI **Sergey Fomel**.

PRC Campus Research Administrators Hosted by Bureau

On May 3, 15 members of the PRC Campus Research Administrators met at the Bureau. The group, composed



of research administrators and other departmental administrators, work together to provide support and expertise to those who develop and administer University of Texas research programs and projects. Hosted by the Bureau's **Julie Duiker**, the group heard a presentation by David Ivey, UT's new Export Control Officer, on current standards and practices regarding access, reporting, and information management.

EAGE and SEG Honor Fomel



Sergey Fomel is the 2011 recipient of the European Association of Geoscientists and Engineers (EAGE) Conrad Schlumberger

award, which is given by EAGE for "an outstanding contribution over a period of time to the scientific and technical advancement of the geosciences, particularly geophysics." Consisting of a medal and a certificate, the award was presented to Sergey at the awards ceremony during the EAGE Annual Meeting in Vienna on May 23. The full citation reads "In recognition of his pioneering work on the subjects of seismic imaging with developments in angle gathers, azimuth moveout correction, velocity independent processing, and velocity continuation. He also contributed to advancements in reservoir description and characterization by developing methods for extracting local attributes from seismic data and characterizing their structural features using plane wave destructors. In addition Sergey has developed open-source seismic processing software, referred to as Madagascar, used currently at many Universities for research and teaching purposes." Two of Sergey's papers, "Local Similarity with the Envelope as a Seismic Phase Detector" and "Seismic Wave Extrapolation Using Low-Rank Symbol Approximation," were named among the Top 30 Presentations at the 80th SEG Annual Meeting in San Antonio. Sergey also received the SEG Best Poster Award.

Scientists Receive GCAGS Awards

In January, **Bob Loucks**, **Rob Reed**, **Steve Ruppel**, and **Uschi Hammes** were notified that they were recipients



of the A. I. Levorsen Award for the best paper presented at the October 10–12, 2010, GCSSEPM/GCAGS meeting in San Antonio. The paper is titled “Preliminary Classification of Matrix Pores in Mudrocks.” This same paper received a Third Place GCSSEPM/GCAGS Grover E. Murray Best Published Paper Award as one of the most outstanding papers published in the GCAGS Transactions volume. **Tucker Hentz** also received a 2010 GCAGS award—Third Place, Gordon I. Atwater Best Poster Award for his poster titled “Regional Lithostratigraphy of the Eagle Ford Shale: Maverick Basin to East Texas Basin.”

Laubach Named AAPG Distinguished Lecturer



This fall, Senior Research Scientist, **Stephen E. Laubach**, began cross-

ing the country on his AAPG Distinguished Lecture tour. The talk, titled “Structural Diagenesis, Resource Plays, the Highlands of Scotland, and Curriculum Development,” was delivered at Michigan State University, East Lansing; Southern Illinois University, Carbondale; University of Missouri, Columbia; Louisiana State University, Baton Rouge; Tufts University, Medford, Massachusetts; and University of Massachusetts, Amherst.

AGL and STARR Authors in the Top Ten



Tim Dooley and coauthors **Michael Hudec** and **Martin Jackson** of the Bureau's Applied Geodynamics Laboratory were presented an Award of Excellence as a “Top Ten” poster presentation at this year's AAPG Convention in Houston for their poster “Canopy Evolution: Deformation Processes and Subsidence Patterns.” This is the third time in the past 4 years that the group has been awarded this recognition. This year, **Steve Ruppel**, **Rob Reed**, **Bob Loucks**, and **Uschi Hammes** of the STARR program were among the AAPG Top 10 Oral Presentations for “Spectrum of Pore Types in Siliceous Mudstones in Shale-Gas Systems.”

Bureau Pub Award Winners

The Bureau's 2011 Author Achievement Awards Dinner was held on Thursday, May 5. The 2011 Publication of the Year Award went to **Julia Gale**, **Rob Reed**, and **Steve Laubach** for their 2010 publication, “Modeling Fracture Porosity Evolution in Dolostone,” published in the *Journal of Structural Geology*. The paper also received the



President's Certificate for Excellence in Presentation at the AAPG Annual Meeting. This well-rounded paper combines careful microstructural observations with numerical modeling to improve fundamental understanding of natural fracture processes in dolostone reservoirs. This past year was a banner year for Bureau publishing: 36 researchers were acknowledged as first author of one or more peer-reviewed publications issued in 2010. **Bill Ambrose**, **Ruarri Day-Stirrat**, **Michael DeAngelo**, **Dallas Dunlap**, **Shirley Dutton**, **Peter Eichhubl**, **Sergey Fomel**, **Greg Frébourg**, **Julia Gale**, **Bob Hardage**, **Tucker Hentz**, **Seyyed Hosseini**, **Martin Jackson**, **Xavier Janson**, **Steve Laubach**, **Bob Loucks**, **Jiemin Lu**, **Jerry Lucia**, **Gang Luo**, **Sojan Mathew**, **Tip Meckel**, **Kitty Milliken**, **Lorena Moscardelli**, **J.-P. Nicot**, **Chris Ogiesoba**, **Jeff Paine**, **Diana Sava**, **Bridget Scanlon**, **Dmitry Volkov**, **Fred Wang**, **Tobias Weisenberger**, **Lesli Wood**, **Michael Young**, **Khandaker Zahid**, **Chris Zahm**, and **Hongliu Zeng** were recognized for their publications. This year also marked the inauguration of the Tinker Family Publisher of the Year Award, which gives each winning BEG author a financial award, in addition to a framed certificate and having their names added to a plaque in the Bureau's lobby.



Roll out the Barrel!

On March 25, five students from the Jackson School (Michael Fairbanks, Ashley Bens, Ben Siks, Erin Miller, and Justin Fitch) competed in the Gulf Coast Region AAPG Imperial Barrel competition in Houston. Our UT team (the Bureau's **Chris Zahm**, far left in photo, is the faculty advisor) took first place out of 10 universities (Auburn, Louisiana State University, Rice, Stephen F. Austin State, Texas A&M, Alabama, University of Houston, University of Louisiana-Lafayette, University of New Orleans, and The University of Texas at Austin). Winnings included a \$3,000 prize for the UT-AAPG Student Chapter and a chance to represent the Gulf Coast region on April 8 in the global competition against the best teams from the remaining 11 AAPG National and International Regions—and our Jackson School team won the global competition! Ninety-six universities around the world participated in the AAPG Imperial Barrel competition this year. Winners of the IBA competition are awarded the coveted Imperial Barrel Cup and \$20,000 for their local AAPG Student Chapter. Thanks to all those that contributed time, effort, and suggestions toward our 2011 UT team.

FRAC Coauthors Recognized

SEPM (Society for Sedimentary Geology) awarded a Certificate of Recognition to **John Hooker, Andras Fall, Guangjian Xu, Autumn Kaylor, Hyein Ahn, Peter Eichhubl, and Steve Laubach** for "an excellent technical presentation at the 2011 SEPM Annual Meeting." The paper is titled



"Predicting Open Natural Fractures in Unconventional Sandstone Reservoirs: Spatial Distribution, Diagenesis, Timing, and Opening Rates."

AGS Honor

Eddie Collins was awarded the Distinguished Service Award by the Austin Geological Society. Eddie has been a member of AGS for a number of years and has led many a field trip for the society. He served as President Elect, President, and Past President 1997–2000; served on the field-trip committee 1990–1991 and again 2000–2003; and he was a member of the Publications Committee 1980–1981.

Foss Elected to CEA Board of Advisors

CEE's **Michelle Michot Foss** was elected to the Board of Advisors of the Consumer Energy Alliance (CEA). According to its website, the CEA is a



"nonprofit, nonpartisan organization that supports the thoughtful utilization of energy resources to help ensure improved

domestic and global energy security and stable prices for consumers....

The mission of CEA is to expand the dialogue between the energy and consuming sectors to improve overall understanding of energy security and the thoughtful development and utilization of energy resources to help create sound energy policy and maintain stable energy prices for consumers."

Clift Receives Outstanding Service Award



The 2011 recipient of the Jackson School's Outstanding Service Award is **Sigrid Clift**, which was presented at the December 14 Holiday Party and Walter Awards Banquet by Jackson School Dean Sharon Mosher. The Dean said of Sigrid:

As the Bureau's Public Information Geologist for more than 2 decades, Sigrid Clift has consistently provided excellent service, information, and resources to JSG and UT staff, to professional geoscientists, to landowners, to legislators, and to teachers and students in Texas. Sigrid has led field trips for industrial associates, students, teachers, and Girl and Boy Scouts, spoken at schools, and forged relationships with a wide variety of private-sector and local, state, and national professionals. She has also been active in the annual Texas Conference for the Advancement of Science Teachers (CAST). Through Sigrid's efforts, the BEG continues to sell

its wildly popular *Texas Rock Kit* to Texas schools and school districts. Sigrid has aided the Austin Geological Society and the Gulf Coast Association of Geological Societies (GCAGS), helping to plan events, meetings and conventions, including the upcoming GCAGS 2012 in Austin, and served as the Petroleum Technology Transfer Council's regional lead organizer. But Sigrid's most outstanding service contribution has been as organizer and host of the annual Earth Science Week (ESW) Career Fair at the PRC Commons, which she has managed for over 10 years, benefitting literally thousands of middle school students and hundreds of teachers in Austin. Sigrid has a strong service ethic and deep commitment to the contributions that the Bureau, Jackson School, and UT provide to the citizens of Texas, the Nation, and the world. To acknowledge her many and varied service activities, please recognize Sigrid Clift as this year's recipient of the Jackson School Outstanding Service Award.

QCL Students on Top again

Kurtus Woolf (striped tie), a Ph.D. Graduate Researcher with the Quantitative Clastics Laboratory (QCL) IA, received second place in the AAPG 2011 Student Poster Awards in Houston in April. Kurtus's poster topic, "Sequence to Architectural Element Framework of the Tuscaloosa Massive Sandstone, Eastern Gulf of



Mexico Province, USA," is part of a larger research program in Jurassic to Cretaceous strata in the Gulf of Mexico. Kurtus also received a \$1,000 AAPG Grants-in-Aid Award for research into the sedimentologic and petrographic nature of the Tuscaloosa Sandstone.



Vishal Maharaj, another Graduate Research Assistant with QCL, who is in his third and final

year of research on how deepwater gravity flows respond to seafloor topography, received a \$500 Houston Geological Society Student Excellence Award. Vishal was also chosen as one of 13 out of 300 applicants to receive a \$7,000 ExxonMobil Research Scholarship, as well as the \$2,500 GCSSEPM Ed Picou Fellowship and, once again, the ConocoPhillips SPIRIT Scholarship. **Dolores Van der Kolk** was the recipient of a \$2,500 AAPG Grants-in-Aid Award for her research into development of Santonian-Campanian clastic wedges of the North



Slope. **Tricia Alvarez**, a Ph.D. aspirant studying structure and sedimentary system interactions along the

plate convergence of the Caribbean, Atlantic, and South American systems near Trinidad and Tobago, received the Gale White Fellowship and another of the ConocoPhillips Spirit Scholarships. Finally, Postdoctoral Fellow (recently hired as Research Associate) **Peter Flaig**, was nominated for an SEPM Best Presentation Award at the AAPG/SEPM Annual Meeting in Houston. He received a certificate of recognition for his technical presentation, "Accommodation as a Control on Coastal-Plain Architectures: Observations and Analyses of the Cretaceous versus Paleocene Prince Creek Formation, North Slope, Alaska." Dolores Van der Kolk and Peter are working on improving our understanding of the Schrader Bluff Formation to Prince Creek Formation transitions that occur in the subsurface, where these units are known as the Ugnu, a major producing unit in the subsurface of the North Slope. They concentrate on remote outcrop work and integration of these detailed observations with core, logs, and seismic in the subsurface. The outcrops probably represent one of the last largest unworked sections of the Cretaceous to Tertiary stratigraphic transition in the world.



Bureau Transitions

Good-Bye, George

Long-time member of the Bureau family, **George Bush**, retired in September, after serving for 24 years at UT and the Bureau, most recently



managing both the Bureau facility and the Core Research Center (CRC). Fresh out of high school George signed up for a tour

of duty in the U.S. Army as a Sgt. E-5 in both Thailand and Vietnam before being honorably discharged. In 1973 George received his B.B.A. in Finance at Texas Tech University in Lubbock, specializing in finance, accounting, and management. In 1986, he signed on at the Bureau's CRC as a Stores Clerk II, in which he became a certified process inspector for the West Texas Waste Isolation Project, supervising core processing. In 1988, George was promoted to Stores Clerk III, and in that capacity he assisted the research staff by providing core plugs and thin-section stubs, a clean and safe work environment, and ordering supplies and equipment. Also during this time, George used time and motion studies to maximize CRC patron services. In 1989 George became the CRC's Storekeeper, in which capacity he supervised the Thin-Section Laboratory, the Sedimentation Laboratory, and sample curation. He also served as Curator in the Curator's absence. In 1992 George was promoted to the position of Curator, in which he managed the CRC, directed patron services, ensured that QA procedures were followed, and organized and coordinated core pickups and deliveries. During George's tenure, the CRC was the repository of more than 500,000 boxes of core and cuttings from wells worldwide. In 2003, George

became Facilities Manager of the Bureau, taking over responsibilities for day-to-day management of the building, providing behind-the-scenes support for in-house meetings, conventions, daily mail service, maintenance of Bureau vehicles, office moves, and inventories of basic equipment. Because George has decided to return to the Bureau part time, his famous Bushian quips should continue for a while longer in the Bureau halls.

So Long, Sally

Sally MacCrae (posing here on the right with long-time friend and co-worker **Wanda LaPlante**), who served for 15 years as receptionist and administrative assistant, was the next



to say farewell. Sally was always the go-to person for office locations, phone service, and Friday seminars. She was

the first to master our new phone system, and her friendly Scottish brogue and cheery demeanor at the front desk will be missed. But Sally will most assuredly have plenty to keep her occupied during her retirement years. As an avid birder, she has always loved to go bird watching. In fact animals of all varieties have been a big part of Sally's life. She has always had at least one dog to keep her company—more often there has been more than one—and a cat or two in the mix. All of these Sally has chosen to rescue from the animal shelter. Sally has been a lover of the arts as well, attending many local theatre productions. Sally's love of rocks and jewelry most likely is what drew her to the Bureau in the first place. Most of her jewelry, which she often sported at the receptionist's desk, was made by her daughter, who sold jewelry in Hawaii, where she lived until recently. Since her daughter and family have moved to Austin, though,

Sally has turned her attention to being a full-time grandmother, keeping busy baby-sitting her two grandsons, Wyatt and Cody.

New Research Staff



Dr. Mohsen Ahmadian joined the AEC team as a Project Manager this year. Mohsen is responsible for managing the funding, implementation, administration, and

reporting of awarded research studies. His research interests include biotech, nanotech, and semiconductor industries; matrix project management, risk assessment, and gap analysis; nanosensors; applied research; and effective technology transfer. Mohsen holds Bachelor's and Master's degrees in biology/chemistry and molecular biology, respectively, from the University of North Texas, Denton, and a Ph.D. in cell regulation from Southwestern Medical Center in Dallas.



Robert Baumgardner recently returned to the Bureau as a Research Engineering/Scientist Associate IV in the Energy Division. After receiving his Master's degree in Geology

from The University of Texas at Austin, Robert was employed by the Bureau during the 1980's and 1990's. He has been involved in Quaternary geology, geologic mapping, geophysical well log interpretation, and stratigraphy and has published more than 60 technical and scientific research articles and reports. Robert is part of Steve Ruppel's Mudrocks group.



A new Research Scientist Associate III in the Environmental Division, **Ruth Costley** is currently focusing her work on GIS and remote sensing, which will initially deal with

ongoing carbon-storage and shale-gas studies. Ruth received her M.S. in GIS in 2007 from the University of Redlands in California after completing a B.S. in Marine Science at Eckerd College in Florida in 2003. Previous positions include Geospatial Analyst at the University of Redlands, Research Assistant at Virginia Polytechnic's Department of Crops and Soil Sciences, and, most recently, GIS Specialist at UT's Institute for Geophysics.



Dr. Andras Fall has been hired on as a Research Associate in the Energy Division. The focus of Andras's research will be development and application of techniques

in destructive and nondestructive fluid-inclusion analysis, artificial diagenesis, and, potentially, in synthetic fluid-inclusion experiments. Andras received his Ph.D. in 2008 and Master's degree in 2005, both in Geosciences from Virginia Tech. He received another M.S. in Geology from the University of Bucharest in 2002. Since December 2008, Andras has worked as a Postdoctoral Fellow at the Bureau, during which time his research has established him as an expert in fluid-inclusion analysis in hydrocarbon systems. His work has also allowed the Bureau to expand its integrated approach to textural imaging and fluid-inclusion microthermometry and barometry.



Dr. Peter Flaig has joined the Bureau ranks as a Research Associate. For the past couple of years Peter has been working as a Postdoctoral Fellow in the Quantitative

Clastics Laboratory. From 2005 through 2009, he worked as a Research Assistant in the Office of Polar Programs Project Collaborative Research: An Ancient Arctic Dinosaur Ecosystem from the Late Cretaceous Prince Creek Formation, North Slope, Alaska—A Natural Case Study in a Greenhouse Climate Model, Department of Geology and Geophysics, University of Alaska—Fairbanks. Last year, Peter spent more than 2 months in Antarctica on an NSF-funded study of the Triassic and Jurassic stratigraphy and sedimentology of the Trans-Antarctic Mountains. Peter is also a freelance photographer.



Dr. Edmund "Ned" Frost III has joined the Bureau as a Research Associate - Carbonate Stratigrapher in the State of Texas Advanced Resource Recovery (STARR)

program. The focus of his research will be to conduct reservoir characterization and regional geological studies in carbonate rocks of Texas. In 2007 Ned received his Ph.D. in Geology from the Jackson School of Geosciences at The University of Texas at Austin, and in 1998 he received his Bachelor's degree in Geology from the University of Colorado. Ned previously worked as a Senior Research Geologist at ConocoPhillips

Subsurface Technology Company in Houston and as a Graduate Research Assistant at the Bureau.



Susan Horvath is a new RSA III/ Data Analyst in the Energy Division. Her current work includes creation of data and GIS information systems for the Sloan Foundation project. Susan

received her Bachelor's degree in Professional Geology in 2003 and her Master's degree in GIS in 2007, both from Eastern Michigan University. Previous positions include work as GIS Analyst for the Arkansas Geological Survey, GIS Technician for Pulaski Area GIS, and GIS and Remote Sensing Intern at the Michigan Tech Research Institute.



Dr. Svetlana Ikonnikova, former Postdoctoral Fellow, is now a Bureau Research Associate - Economist in the Energy Division—providing exper-

tise on the STARR program and anchoring above-ground aspects of the new U.S. Shales Project funded by the Sloan Foundation grant. Svetlana received her Ph.D. in Economics and Management Science in 2007 from the Humboldt University of Berlin and B.S. and M.S. degrees in Applied Physics and Mathematics in 2001 and 2003, respectively, from the Moscow Institute of Physics and Technology. Svetlana has a number of published articles and presentations on energy economics. Her initial focus will be to conduct research on U.S. shale resource plays, examining economic assumptions implicit in scenarios that achieve selected levels of future gas production.



Dr. Alexander Klovov is a new Postdoctoral Fellow at the Bureau, who holds both M.S. and Ph.D. degrees in Geophysics from Gubkin Russian State University of Oil and Gas,

Moscow. He has worked as a research scientist at OPERA in Pau, France, as well. Alexander specializes in seismic imaging, migration velocity analysis, and diffraction imaging and has joined Sergey Fomel's research group.



Dr. Di Long, a new Postdoctoral Fellow, has research interests in land-surface fluxes (e.g., radiation and evapotranspiration) model-

ing from remote sensing, scale/scaling issues in satellite-based ET estimation, remote sensing in hydrologic modeling, hydro-

logic response to climate change and land use/cover change, and entropy theory in hydrological and environmental engineering. Di has a Ph.D. in Hydrology and Water Resources from Texas A&M, a Master's in Remote Sensing and Geography from the Institute of Geography at the Chinese Academy of Sciences in Beijing, and a Bachelor's in Hydrology and Hydraulics from Tsinghua University in Beijing. He will be working with Bridget Scanlon's group.



Dr. Jiemin Lu is now a Bureau Research Associate working in the Gulf Coast Carbon Center in the Environmental Division. The focus of Jiemin's research

includes reservoir and seal evaluation for CO₂ EOR and geological storage, diagenesis and petrophysics of clastic rock, CO₂ interactions with aquifer and seal, and geochemistry of fluid-rock interaction in sedimentary rocks. Jiemin received his Ph.D. in Geology at Edinburgh University in Scotland and his M.S. in Tectonics at Peking University in China.



Dr. Gang Luo has joined the Bureau as a Research Associate - Geomechanical Modeler in the Energy Division. His research will emphasize using numerical modeling to

explain overpressure and stress conditions around salt structures—two critical issues for industry partners who drill wells adjacent to and below salt structures. Gang received his Ph.D. in Computational Geodynamics from the University of Missouri-Columbia in 2009 and his M.S. in Geophysics in 2003 from Peking University. He has been a Postdoctoral Fellow at the Bureau since August 2009, when his research focused successfully on prediction of stress states around salt structures from finite-element models.



Dr. Sojan Mathew became a Bureau Research Associate in February in the Environmental Division. Sojan's new work will center on application of remote sensing and

GIS in the classification of macrophytes as an indicator of nutrient load in Lake Constance, Germany: rectification and mosaicking of aerial and remote sensed images; mapping of submerged aquatic microphytes; classification of macrophyte distribution and its integration in GIS; and accuracy assessment of submerged

aquatic microphyte classification. Sojan holds a Ph.D. in Geography from the University of Guelph in Ontario, Canada; an M.S. in Agricultural Sciences, Food Security, and Natural Resource Management from the University of Hohenheim in Stuttgart, Germany; and an M.S. in Soil and Water Conservation Engineering from Tamilnadu Agricultural University in Coimbatore, India.



Dr. Patrick Mickler is a new Research Associate - Hydrogeologist in the Environmental Division. Patrick will be focusing on building new programs in

hydrologic research, such as karst systems and water-resource assessments, which will expand the Bureau's strengths in recharge studies and water-quality assessments. These areas of research are particularly important, given the challenges presented by current drought conditions in Texas. Patrick received his Ph.D. in Geology from The University of Texas at Austin in 2004 and his M.S. in Geology in 1998 from the University of Cincinnati. He was previously a lecturer at California State University, Bakersfield; a Postdoctoral Research Scientist at The University of North Carolina at Chapel Hill; and a Graduate Research Assistant in the Jackson School of Geosciences.



Dr. Zahra Mohammadi is a Postdoctoral Fellow in the Energy Division who specializes in polymer design, ligand grafting, and conjugation reactions; particle

engineering and colloidal stability, bulk and water-in-oil microemulsion polymerization; enhanced oil recovery through wettability alteration; design and synthesis of novel nanoparticles as scale inhibitors; application of magnetic nanoparticles in reservoir characterization; and design and optimization of biomimetic functional polymers as metal chelators. Zahra has M.S. and Ph.D. degrees in Chemical Engineering from the University of Kansas. She works in Farzad Javadpour's nanogeosciences lab.



Peter Polito, new Research Scientist Associate III with Peter Flemings' group, lists geomechanical properties of channel-bed material and the corresponding

effect on fluvial bedrock incision and sediment transport, along with fluid transport through fine-grained media, as his research interests. Peter received his B.S. and M.S. degrees in Geology and Applied Geosciences, respectively, from San Francisco State University.



Dr. Karl Schleicher, a part-time Senior Research Fellow, works closely with Sergey Fomel's group developing and using new software. He deployed advanced seismic

processing technology for GSI, Halliburton Geophysical, Western Geophysical, GDC, AGS, and PGS before retiring in early 2010. Karl is currently processing public domain seismic data with open software to validate university research and accelerate commercialization.



David Smith has signed on as a Research Scientist Associate II Database Analyst in the STARR program. David's areas of expertise include well log correlation,

lease confirmation, and prospect generation. David holds a B.S. in Geology from The University of Texas at San Antonio.



Patrick L. Smith has joined the Bureau as a Research Scientist Associate III. Patrick's schooling includes a B.S. in Geology from Michigan State University in Lansing, as

well as postgraduate work at the University of Minnesota in Duluth and Huston-Tillotson College here in Austin. Patrick specializes in laboratory management, electron and scanning probe microscopy, analytical/HR TEM, and X-ray diffraction and optical/electron microscopy.



The Bureau welcomes **Dr. Alex Sun** as a Research Scientist in the Environmental Division. Previously Alex was Principal Research Engineer at the Southwest Research

Institute. He has an outstanding academic and professional background, with B.S. and M.S. degrees in Civil and Environmental Engineering from UCLA and UC Berkeley, respectively, and a Ph.D. in Environmental Water Resources from UC Berkeley in 2000. His research interests include developing decision support systems for regional water-resource and water-quality management, data fusion, multiscale numerical modeling and data assimilation

for improving water-availability assessment, environmental remediation and CO₂ sequestration monitoring, and developing computational and stochastic techniques to quantify hydrologic model uncertainty and risks. Alex has worked in research and industry for 10 years since completing his Ph.D. degree and has nearly 20 peer-reviewed articles, and on many of these he was lead author. Alex will provide research support for the Gulf Coast Carbon Center (GCCC) in geologic sequestration of CO₂ and related groundwater issues.



New Postdoctoral Fellow, **Dr. Estibalitz Ukar**, received a Bachelor's degree in Geology from Euskal Herriko Unibertsitatea/Universidad del País Vasco, Spain, in 2003,

and a Ph.D. in Geological Sciences from The University of Texas at Austin in 2010. Esti's areas of expertise are in structural geology and tectonics, and her technical skills include GIS, EMPA, SEM, CL, XRD, PERPLE_X, AND THERMOCALC (basic). Esti is working in the FRAC group.



Dr. Jaclyn Wiggins-Camacho, Postdoctoral Fellow working in Tongwei Zhang's group in the Energy Division, has research interests in quantitative analysis, materials characterization, and surface science; alternative and unconventional energy; and environmental chemistry and nanotechnology. Jaclyn holds a B.A. in Biology-Chemistry from Scripps College in Claremont, California, and a Ph.D. in Chemistry from The University of Texas at Austin.



Dr. Brad Wolaver joined the Bureau as a Research Associate - Hydrologist in the Environmental Division this year. His research will focus on building new programs in

hydrologic research in areas such as karst systems and water-resource assessments, including sustainable groundwater management for people and the environment, particularly in semiarid and arid regions. Brad received his Ph.D. in Geology in 2008 from The University of Texas at Austin and his M.S. in Hydrology in 1999 from the University of Arizona, Tucson. Previously Brad was a Research Fellow at Flinders University in Adelaide, Australia, where he created a hydrogeologic conceptual model of the regional aquifer and spring complex

on the west margin of the Great Artesian Basin. His results will help guide groundwater development and preserve spring discharge.



Dr. Xianli Xu is a new Postdoctoral Fellow in the Environmental Division, whose research interests include climate change and biogeochemical cycles, vadose zone hydrology and ecohydrology, ecosystems function and service (restoration and assessment), soil threats assessment (sealing, compaction, erosion, and carbon loss), and GIS and remote sensing. Xianli received a Ph.D. in Ecology from the Research Center for Eco-Environmental Sciences at the Chinese Academy of Sciences in Beijing and an M.S. in Physical Geography from Beijing Normal University. Xianli is now part of Bridget Scanlon's group.



Dr. Mehdi Zeidouni recently joined the Bureau as a Research Associate - Reservoir Engineer in the Environmental Division.

Mehdi's research will focus on reservoir modeling and monitoring design related to CO₂ sequestration. He received his Ph.D. in Reservoir Engineering from the University of Calgary, Canada, in spring of 2011. He was awarded a Master's degree in Reservoir Engineering in 2003 from Delft University of Technology, Delft, The Netherlands, and a Bachelor's degree in Petroleum Engineering in 2000 from the Abadan Institute of Technology, Ahwaz, Iran. Mehdi also has 8 years of experience in reservoir engineering and scientific research in the oil industry and at academic institutions.



A new Postdoctoral Fellow, **Dr. Xiaodong Zhang**, was added to the Bureau ranks in the fall. Xiaodong holds Bachelor's and Master's degrees in Environmental

Engineering from Tsinghua University in Beijing and a Ph.D. in Environmental Systems Engineering from the University of Regina, Canada. His areas of expertise include energy systems planning and CO₂ sequestration, risk assessment for petroleum-contaminated sites, groundwater modeling and remediation, water resources management, and solid waste and sustainable resources management. He is working with Ian Duncan in the Environmental Division.

New Support Staff



Sharan Happel is a new Accounting Technician working in Beth Ellison's group in Administration. Sharan has an Associate of Arts degree from Loyola

University in New Orleans, with coursework in professional development, business and administrative processes, computer applications, and interior design. Her areas of expertise include accounting, audit, and business processes. Before coming to the Bureau, Sharan worked elsewhere on the UT campus, as well as for the hotel industry.



Robert Newsham

has been hired as the Bureau's Web Developer in the Media Department. Robert has been working the last few years as a

temp, but he was finally made a permanent employee this year. An expert in the field of software programming, Robert has a B.S. degree in Computer Science from the University of Hawaii at Manoa. In addition to maintaining the Bureau's website, Robert looks for ways to improve processes and data flow through automation and integration of existing resources. Case in point: he has recently been working on updating and streamlining the Graphics archive.



Erin Parr has joined the Bureau ranks as a Human Resources Assistant III. Erin lists her areas of expertise to include recruiting and the UT Human Resource

Management System. Erin comes to us by way of Facilities Services, UT Personnel Services, and, before that, the Office of the Registrar, Student Records, and Neubus, Inc.



Patty Romano is the Bureau's new HR Manager. With a Bachelor's in Applied Learning and Development from UT, Patty specializes in web development, training,

and the Human Resource Management System (HRMS). Before coming to the Bureau, Patty was on the HRMS team in the UT Office of Accounting. She also worked at UT Information Technology Services, the Round Rock Independent School District, and Convio, Inc.



Joseph Smitherman

is a new Stores Clerk in Nathan Ivicic's group at the Core Research Center in Austin. A 2009 graduate of Lago Vista High, Joseph was a dog trainer

at Petsmart for 2½ years before coming to the Bureau. Joseph helps set up the viewing room and sampling core in the saw room, as well as working in the CRC warehouse.

Bureau Publications

The Bureau produced four new publications in 2011.

Two new Miscellaneous Maps,

Geologic Maps of the Upper Cretaceous and Tertiary Strata, Big Bend National Park, Texas, R. W. Cooper, coordinator.

This six-sheet set of geologic maps and cross sections presents new interpretations on the outcrop pattern and complex structure within the Upper Cretaceous Del Rio, Buda, Boquillas, Pen, Aguja, Javelina, and Cretaceous-Tertiary Black Peaks Formations of Big Bend National Park. Also, Boquillas marine deposits have been subdivided in new detail, and key locations have been tied to fossils recently archived at the Texas Memorial Museum. The mapped area includes a location for the global stratotype section and point (GSSP) of the Turonian-Coniacian Stage Boundary to the International Union of Geological Sciences Subcommission on Cretaceous Stratigraphy. The maps show many of the popular areas for tourist (and field-trip) visitation within the park. The geologic map



set complements, and in some cases updates, other Bureau publications on the geology of

Big Bend National Park, such as Publication 6711 (*Geology of Big Bend National Park, Brewster County, Texas*), Guidebook 7 (*The Big Bend of the Rio Grande, a Guide to the Rocks, Landscape, Geologic History, and Settlers of the Area of Big Bend National Park*), GQ Map 54 (*Structural Geology of Sierra del Carmen, Trans-Pecos, Texas*), MM0046 (*Geologic Map of the Glenn Spring Quadrangle, Big Bend National Park, Texas*), and MM0048 (*Geologic Map of Mariscal Mountain, Big Bend National Park, Texas*). Also, geologic information displayed on the 1:24,000-scale MM0050 (*Geologic Maps of the Upper Cretaceous and Tertiary Strata, Big Bend National Park, Texas*), as well as on MM0046 and MM0048, was used by the U.S. Geological Survey (USGS) and the National Parks Service for the new 1:75,000-scale U.S. Geological Survey geologic map for the entire Big Bend National Park. **MM0050, \$30.00.**

Geologic Map of the East Part of Cleburne, Texas, 30 × 60 Minute Quadrangle: South Fort Worth–Interstate 35W Corridor, by Edward W. Collins and Robert W. Baumgardner Jr. This geologic map of the east part of the Cleburne 30 × 60 minute quadrangle, scale 1:100,000, has been constructed through mapping and digital compilation of twenty 1:24,000-scale geologic work maps. The map and related data 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. Geology of the area consists of Cretaceous (Albian to Coniacian) limestone, argillaceous limestone, marl, shale, and sandstone units composing more than 1,500 ft of Cretaceous shelf and shore-zone deposits. This stratigraphy includes the Woodbine and Paluxy Sandstones, sources of sand within the unit's outcrop belt and important aquifers in the subsurface. Edwards and Comanche Peak limestones are also resources for lime and aggregate. Some local limestone pits are within the Georgetown Formation. **MM0051, \$12.00.**

a new atlas,

The Salt Mine: a Digital Atlas of Salt Tectonics, by Michael R. Hudec and Martin P. A. Jackson. This hard-bound four-color volume and accompanying interactive DVD helps scientists quickly sort through the entire spectrum of knowledge of salt tectonics, isolate relevant information, and find pathways to more-detailed information. *The Salt Mine* DVD is an



HTML-based atlas of salt structures and associated sediment geometries that contains more than 1,300 annotated images of salt structures, with detailed captions that discuss key principles. All images are grouped into structural styles on the basis of a geometric classification and include field exposures (outcrop views, geologic maps, aerial photographs, and satellite images), seismic sections, geologic cross sections, conceptual sketches, and animations. Director Scott Tinker says of *The Salt Mine*, "This has been an effort that began decades ago scientifically. And the formal effort some 10 years ago. The science, graphics, editing, and total production are monumental." The book has been published as Bureau of Economic Geology Udden Book Series No. 5 and AAPG Memoir 99. **US00005, \$70.00.**

and a new Report of Investigations,

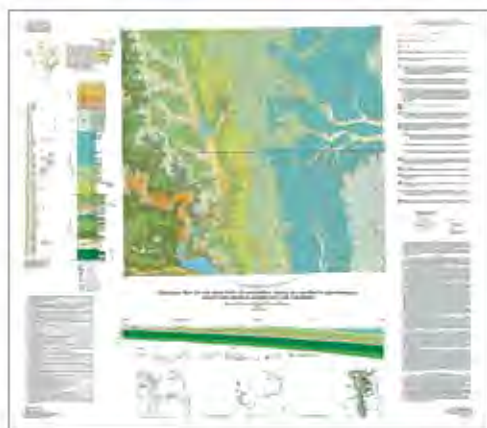
Sequence Stratigraphy, Depositional Systems, and Hydrocarbon Play Analysis of the Pennsylvanian Cleveland Formation and Marmaton Group, Anadarko Basin, North Texas and Western Oklahoma, William A.

Ambrose, editor. The primary objective of the three articles that compose this report is to provide a detailed review of the stratigraphic and structural attributes and controls on productivity and future potential of the Cleveland Formation and



Marmaton Group by integrating chronostratigraphic, depositional-facies, and play analysis. This investigation expands on previous studies of the

Cleveland Formation by Hentz (1994a, b). It provides more detailed analysis of facies by using a larger data set, as well as by relating sequence-stratigraphic and facies controls on sandstone-body distribution and reservoir continuity. This study also includes a play analysis of the Marmaton Group, which has a depositional origin similar to that of the Cleveland Formation. The study uses a data set consisting of 1,127 wells and 5 conventional cores with approximately 250 ft (~75 m) of section from the Cleveland Formation, as well as production data from both the Cleveland Formation and Marmaton Group from more than 900 wells. This is the first study to define, map, and characterize gas and oil plays systematically in the Cleveland Formation and Marmaton Group using a sequence-stratigraphic and structural framework. Robust sequence-stratigraphic and depositional-facies frameworks that accurately predict the complex sandstone-body and facies geometry within the Cleveland Formation and Marmaton Group are necessary for controls on their reservoir quality and continuity to be better understood. **RI0275, \$25.00.**



Peer-Reviewed Publications

by Bureau Researchers

Articles in Peer-Reviewed International Journals

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- Alkhalifah, T., and Fomel, S. B., 2011, The basic components of residual migration in VTI media using anisotropy: *Journal of Petroleum Exploration and Production Technology*, v. 1, p. 17–22.
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- Burton, D., Dunlap, D. B., Wood, L. J., and Flaig, P. P., 2011, Lidar intensity as a remote sensor of rock properties: *Journal of Sedimentary Research*, v. 81, p. 339–347.
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- Fomel, S. B., 2011, Theory of 3-D angle gathers in wave-equation seismic imaging: *Journal of Petroleum Exploration and Production Technology*, v. 1, p. 11–16.
- Frohlich, C., Hayward, C., Stump, B. B., and Potter, E., 2011, The Dallas–Fort Worth earthquake sequence: October 2008 through May 2009: *Bulletin of the Seismological Society of America*, v. 101, no. 1, p. 327–340.
- Fu, Q., and Qing, H., 2011, Medium and coarsely crystalline dolomites in the Middle Devonian Ratner Formation, southern Saskatchewan, Canada: origin and pore evaluation: *Carbonates and Evaporites*, v. 26, p. 111–125.
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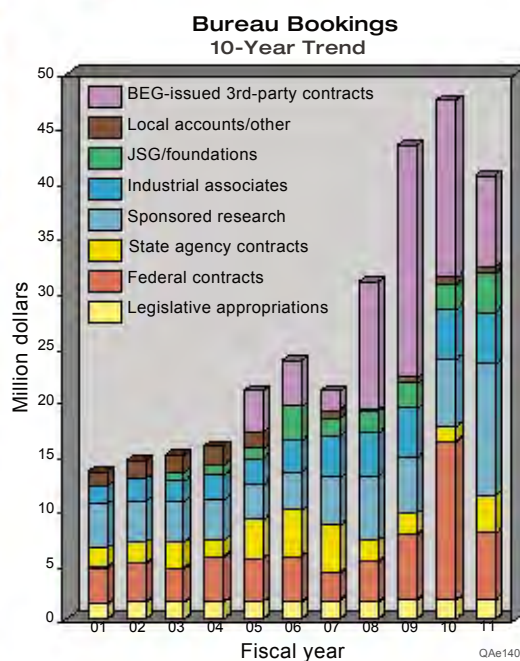
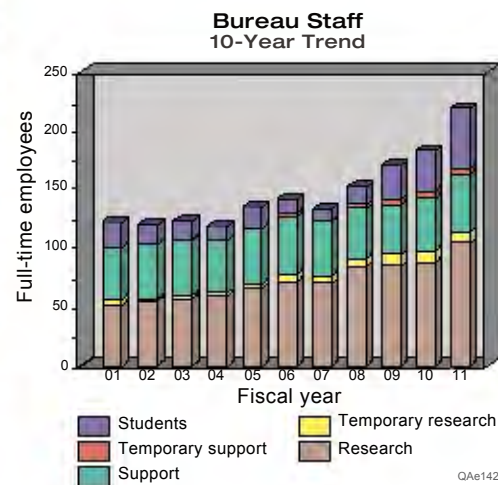
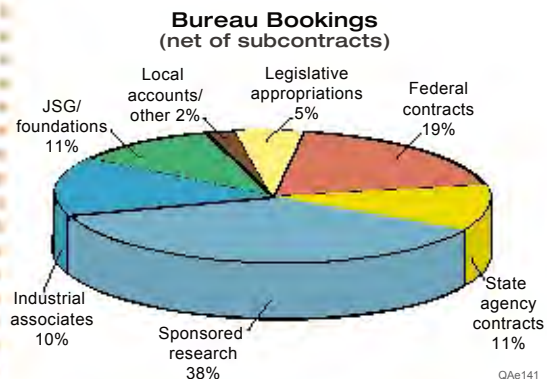
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