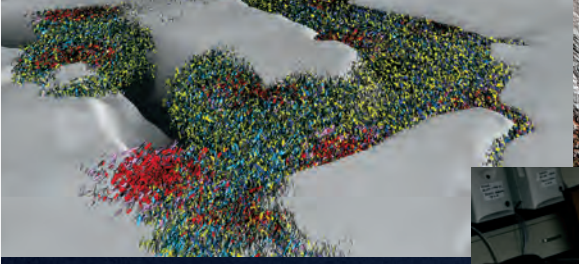
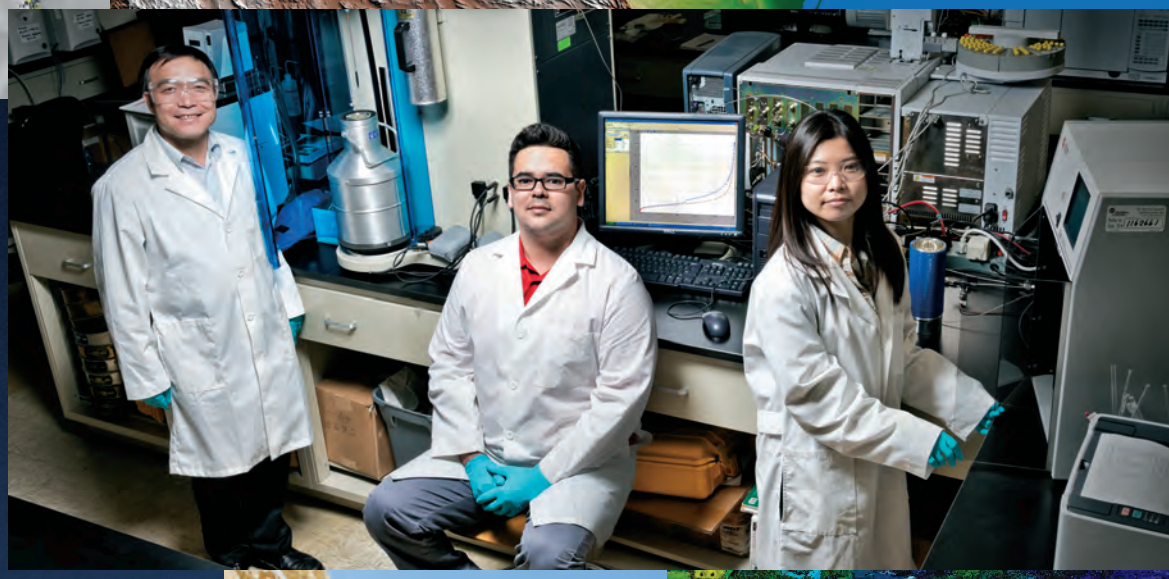
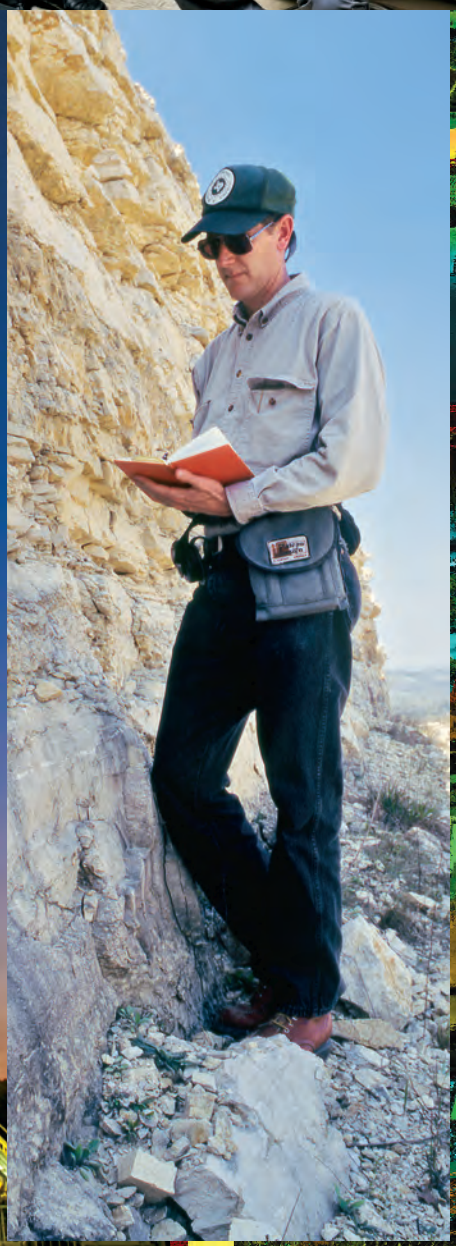
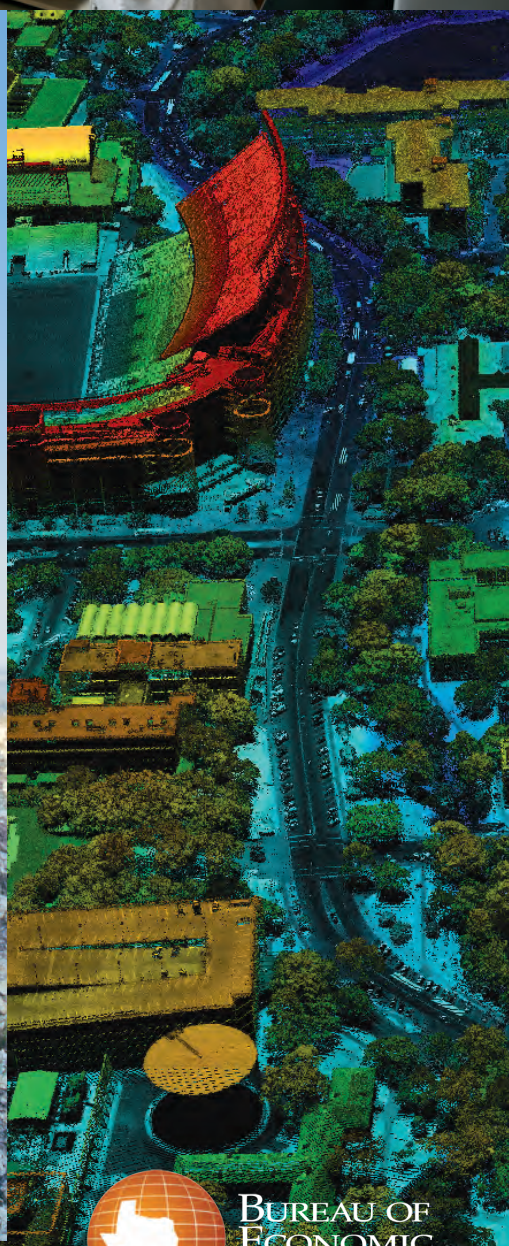


RESEARCH CONSORTIA

2016







BUREAU OF ECONOMIC GEOLOGY

Scott W. Tinker, Director

Research Consortia at the Bureau

Director
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Associate Directors
Eric C. Potter,
Energy Division
Michael H. Young,
Environmental Systems Division
Jay P. Kipper,
Administration and Finance

Research and
Administrative Office
and Laboratories
J. J. Pickle Research Campus
10100 Burnet Road
Austin, Texas 78758-4445
512-471-1534, Switchboard
512-471-0320, Public Information
512-471-0140, Fax
512-471-7144, Publication Sales
1-888-839-4365, Toll-free phone (USA)
1-888-839-6277, Toll-free fax (USA)

Media Manager
Cathy J. Brown

Editor
Stephanie D. Jones

Senior Graphics Designer
Jamie H. Coggin

Photography
David M. Stephens

The Bureau of Economic Geology: Partner with Industry

The Bureau of Economic Geology conducts research on subjects of high interest to the energy industry and environmental firms, and a broad spectrum of companies actively participate in its 13 industry consortia. These unique industry partnerships study research subjects as diverse as salt tectonics, carbonate reservoir characterization, natural fractures and geophysics, carbon storage, nanotechnology, quantitative clastics, computational seismology, mudrock reservoirs, and energy economics.

Collectively, these 13 consortia enjoy the support of over 70 companies globally, with some companies participating in as many as 9 separate programs. Each industry consortium was designed to complement industry efforts to understand a key exploration, production, and/or environmental or economic problem. Participation is on a subscription basis. Member benefits vary, but generally include first-look privileges to research outcomes, access to research teams, invitations to annual review meetings, and office visits by researchers for presentation and interaction. Members also benefit from interactions with counterparts in fellow sponsoring companies.

Each Bureau research consortium has a dedicated team of full-time researchers, including postdocs. Many host talented graduate students. The teams combine seasoned experts with early-career specialists. A number of researchers have industry backgrounds, and all share a passion for university-based research.

We invite you to review this brochure and to contact the principal investigator of any program of interest to you. If you would like further information about these industrial consortia or the breadth of your company's engagement with the Bureau, please contact us at http:\\www.beg.utexas.edu or by phone at 512-471-1534.

UT Bureau of Economic Geology

Who We Are

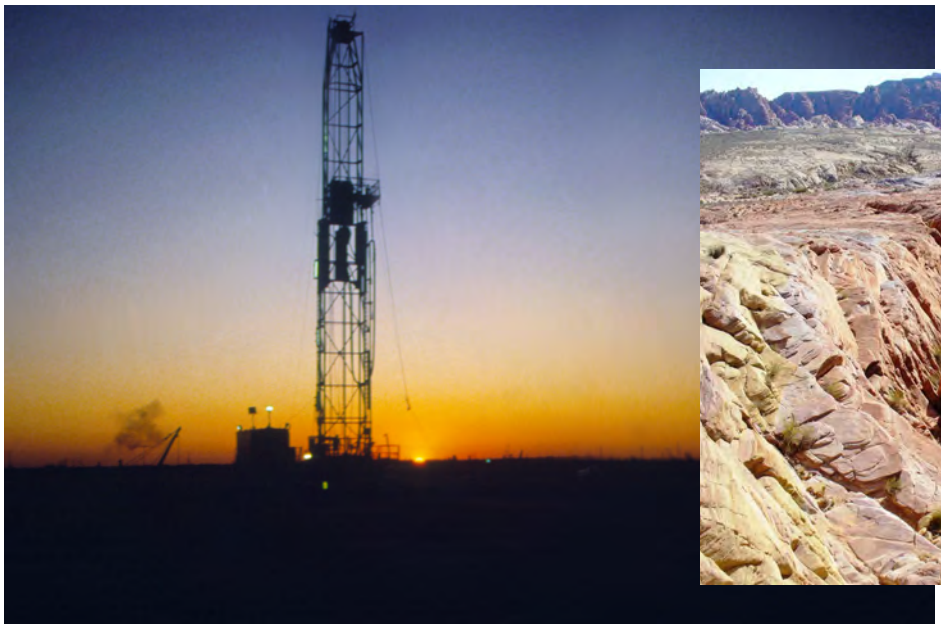
Established in 1909, the Bureau of Economic Geology is the oldest and second-largest organized research unit at The University of Texas at Austin. The Bureau functions as the State Geological Survey of Texas and has been an integral part of the development of the state's oil and gas industry through the years. Bureau researchers spearhead basic and applied research projects globally in energy resources and economics, coastal and environmental studies, land resources and use, geologic and mineral mapping, hydrogeology, geochemistry, and subsurface nanotechnology. The Bureau provides advisory, educational, technical, and informational services related to the resources and geology of Texas, the nation, and the world.

Bureau Programs

The Bureau is an international leader in a number of research thrusts, working at the intersection of energy, the environment, and the economy, with strengths that include:

- Unconventional oil and gas exploration and production
- Salt tectonics
- Natural fractures and structural diagenesis
- Reservoir characterization in carbonates, mudrocks, and sandstones
- Carbon storage in geological reservoirs
- The water-energy nexus
- Energy economics

Talented people are the Bureau's formula for success. The research staff includes more than 120 scientists, engineers, and economists, representing 27 countries, working in integrated, multidisciplinary research teams. Together with 60 skilled graduate students and 15 post docs, they find solutions to the world's greatest challenges in energy and environmental research.



Partnerships

Partnerships drive strategy, innovation, and investigation, and the Bureau engages partners, new and old, on a multitude of levels. Investments in Bureau research provide significant returns. Corporate partners participate in and gain vital new insights from the Bureau's many productive industrial research consortia, which are described herein. Government, agency, foundation, and nongovernmental organization partners include the State of Texas, the Alfred P. Sloan Foundation, the U.S. Department of Energy, and the Environmental Defense Fund.

Facilities

Superb facilities and equipment, some cofunded by industry, give researchers the tools they need to find objective, rock-based research answers.

- More than 15 individual laboratories hosting research teams investigating everything from nanoparticles to shale porosity and permeability
- Three massive well-core research and storage facilities, in Houston, Austin, and Midland—collectively, what may be the largest archive of rock material in the world
- One of the largest collections of well logs in the United States
- An extensive inventory of modern imaging devices and integrated technologies for outcrop and land-surface mapping

Results

Over 100 years of producing research results have earned the Bureau an unparalleled reputation. Successful outcomes can be measured by many yardsticks, and Bureau researchers more than measure up:

- Over 100 peer-reviewed articles and books published annually
- Hundreds of abstracts and articles published each year in *Conference Proceedings* volumes
- More than 50 keynote addresses made annually
- Bureau researchers are frequently presidents of international professional societies and editors of major professional journals, and are recognized by their peers with top medals and awards in their fields

Advanced Energy Consortium

Mission

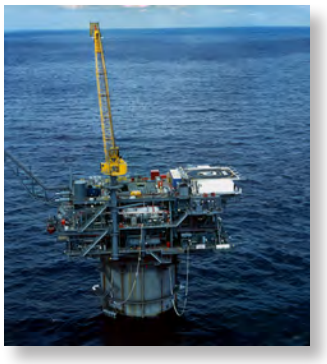
The primary goal of the Advanced Energy Consortium (AEC) is to develop intelligent subsurface micro- and nanosensors that can be injected into oil and gas reservoirs to help characterize the space in three dimensions and improve the recovery of existing and new hydrocarbon resources. The consortium also believes that there is near-term potential to increase the recovery rate in existing reservoirs by exploiting the unique chemical and physical properties of materials at the nano scale.

Value

In 2006, the U.S. Department of Energy reported that approximately 67 percent of all discovered U.S. oil remains in place, estimating that perhaps one-quarter of this oil can be recovered; these potential reserves could add hundreds of billions of barrels to the domestic supply. This remaining oil in place is not easy to find or remove, however. Despite current use of 3D and 4D seismic detection, advanced downhole electrical, controlled source electromagnetic (CSEM), and sophisticated modeling and simulation technologies to improve the understanding of oil and gas reservoirs, these techniques are still lacking in resolution and/or deep penetration into reservoir lithologies. In fact, with the exception of seismic and CSEM methods, most sensing technologies penetrate and provide information about the reservoir only inches from the well bore. AEC research aims to develop sensors that would have the ability to migrate out of the well bores and through pores of the surrounding rock to collect data about the physical and chemical characteristics of hydrocarbon reservoirs, thus helping to "illuminate" the reservoir.

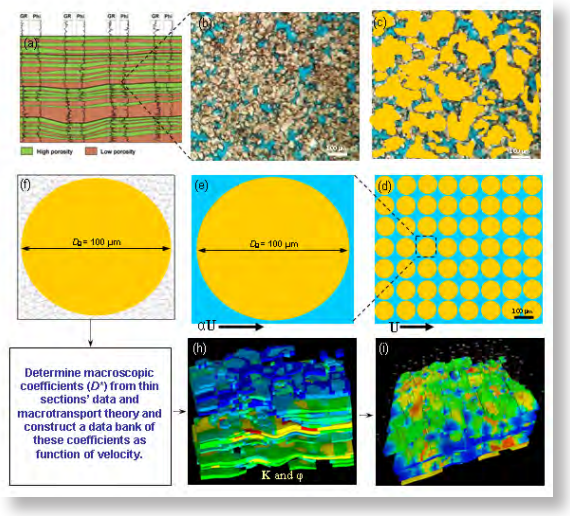
Challenges

Hydrocarbon reservoir environments are harsh: Conventional conditions include depths of thousands of feet, operating temperatures of 250°C or more, and pressures of up to 15,000 pounds per square inch bathed in complex mixtures of oily, briny, waxy, and acidic fluids of two or more phases. Conventional micro-electronic sensors could not survive under these conditions, let alone operate and communicate. Porosity, permeability, and rock-type variations might further constrain the free flow of sensors through reservoirs.



Research

The consortium funds research at leading universities, labs, and private industrial facilities around the world that are developing functional micro- and nanoscale sensor technologies. The current portfolio of applied research projects includes:



- Fundamental studies of nanomaterial behavior in fluidic reservoir environments
- Microelectromechanical system (MEMS) sensors
- Nanoelectromechanical system (NEMS) sensors
- Passive or nanoscale material sensors
- Paramagnetic nano contrast agents

The AEC is actively pursuing new technological advancements that could enable autonomous, self-powered sensors that communicate parametric data to identify bypassed oil and gas.

Members

The consortium is managed by the Bureau of Economic Geology. Membership is limited and requires a multi-year commitment.

Contact

Jay Kipper, jay.kipper@beg.utexas.edu, (U.S.) 512-475-9505
www.beg.utexas.edu/aec

Applied Geodynamics Laboratory

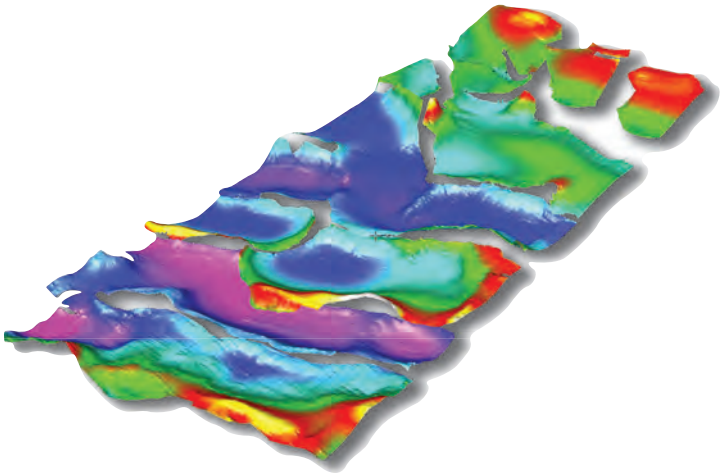
Salt Tectonics

Mission

Pure and applied research in salt tectonics has been a strong component of the Bureau's research program since the late 1970's. At the heart of this research is the Applied Geodynamics Laboratory (AGL), an industry-funded consortium dedicated to producing innovative concepts in salt tectonics. Research comprises a mix of physical and mathematical modeling; seismic- and field-based mapping; and structural–stratigraphic analysis of some of the world's most spectacular salt basins—including those of the Gulf of Mexico, West Africa, Brazil, the Mediterranean, and the Canadian High Arctic. Research has also been applied extraterrestrially to Mars and Triton.

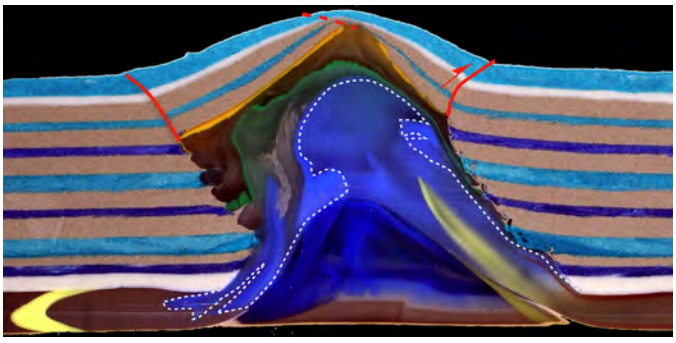
Impact

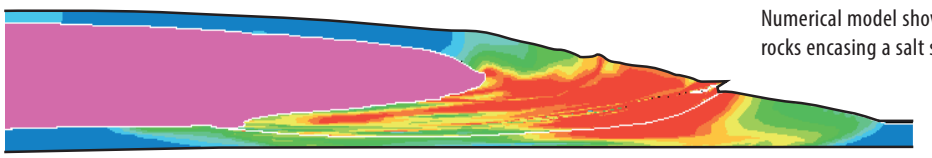
Concepts and terminology pioneered by AGL in the last 25 years have profoundly influenced our understanding of salt tectonics and are now widely disseminated throughout the oil industry. AGL strives to effectively communicate these results via a variety of media, including *The Salt Mine: A Digital Atlas of Salt Tectonics,* a book and interactive DVD designed to be the most comprehensive collection of salt-tectonic images and animations ever assembled.



Challenges

- To develop a conceptual framework for the full range of salt tectonics
- To analyze connections between physical models, mathematical models, seismic data sets, and field examples from all over the world
- To disseminate complex technical information to a constantly shifting spectrum of industrial and academic supporters

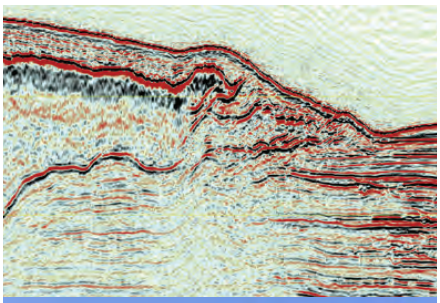




Numerical model showing contours of strain in sedimentary rocks encasing a salt sheet advancing to the right

Major Concepts Developed

- Salt weld
- Salt canopy
- Reactive, falling, and squeezed diapirs
- Shape of passive diapirs and sheets
- Fault families (with University of Colorado)
- Extrusive salt sheets (with BP, Exxon)
- Extensional turtle and mock turtle
- Mechanics of salt-sheet advance
- Origin of minibasins
- Intrusive salt plumes
- Salt sutures



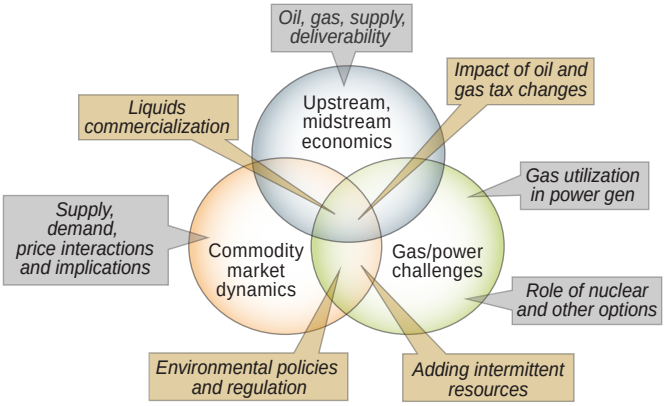
Contact

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

Center for Energy Economics

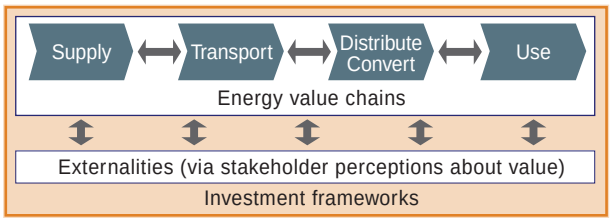
Who We Are

Based within UT's oldest largest research organization, the Bureau of Economic Geology, CEE performs research and provides training and outreach on energy economics, markets, and frameworks for commercial and strategic investment. CEE is externally funded through research grants and contracts, corporate and government partnerships, and our training programs and partnerships.



Mission

CEE conducts applied research on energy-value-chain economics and educates stakeholders to improve public policy and investment for economic development. *"We develop viable solutions to problems across energy value chains and frameworks, identifying trade-offs and addressing externalities."*



CEE Training

Using our knowledge base, CEE prepares and delivers training on economic fundamentals of energy value chains, the roles of industry and government, and technology and investment frameworks for commercialization. We also facilitate Commercial Frameworks©; stakeholder interactions (business–government–public); engineering, production, and procurement management; and energy finance.

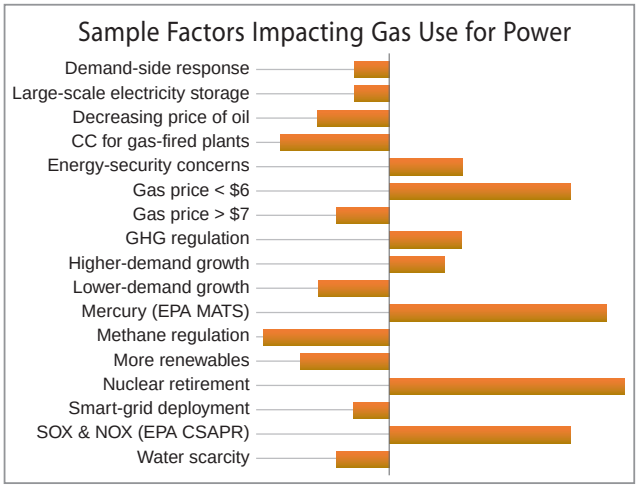
APPLIED RESEARCH IN ENERGY ECONOMICS
With international collaborations

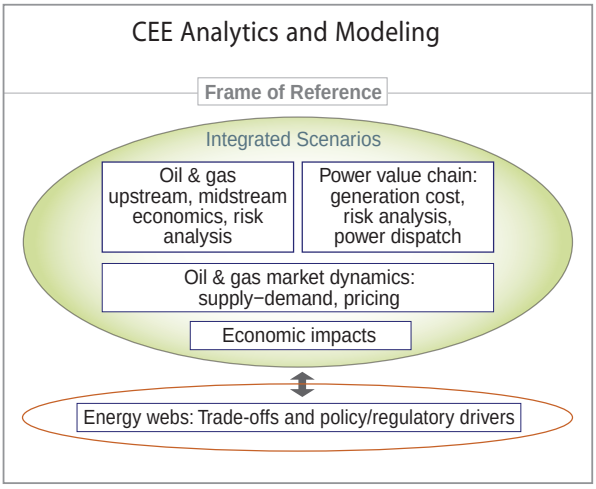
OUTREACH
Research papers and publications, forums, web resources

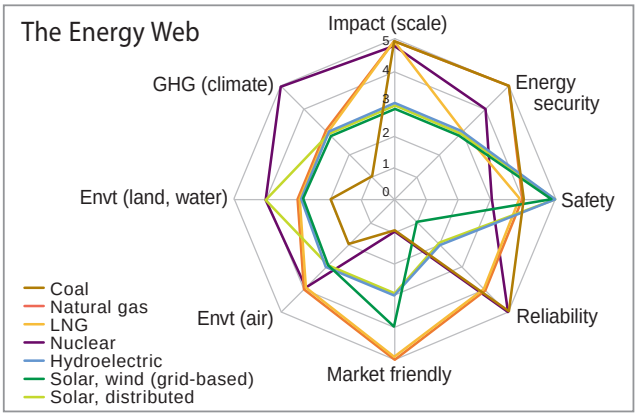
TRAINING AND EDUCATION
McCombs Executive Education and custom programs

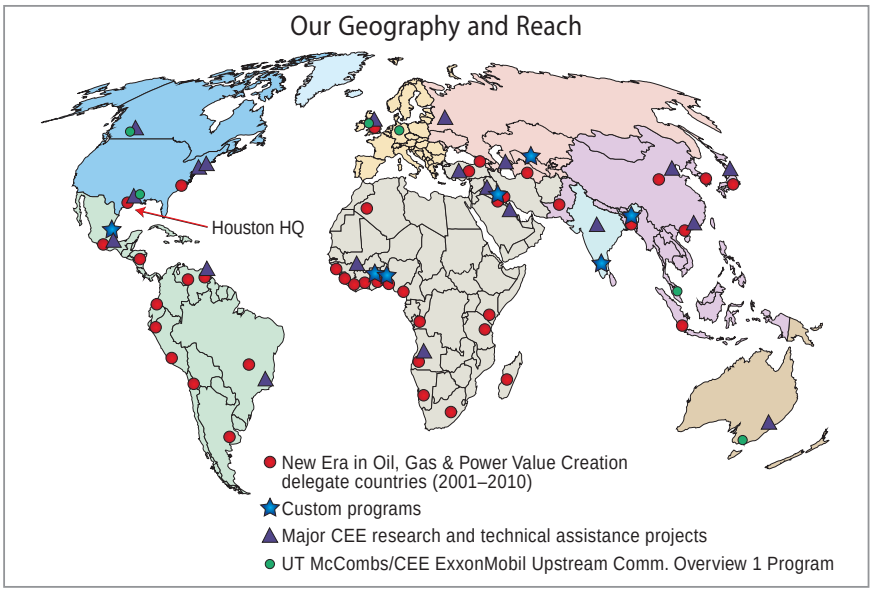
Current Activities

- **Natural gas markets:** commodity market trends and demand-side analysis including modeling EPA regulations; gas use in power generation; database for petrochemicals and other industrial demand; exports via pipelines or LNG; use of natural gas in vehicles; residential and commercial requirements
- **Electricity markets:** economics of generation technologies, demand response, storage, ancillary services and other design issues
- **Critical energy infrastructure:** value chain costs and other considerations such as stakeholder risk, including oil and gas pipelines; processing; refining to connect oil, gas, liquids production to markets; grids
- **Energy webs:** evaluating energy options across multiple dimensions
- **U.S. producer and national oil company benchmarking:** cost structures, performance, financial state of companies, funding sources and capital market risk









Contact

Michelle Michot Foss, Chief Energy Economist and Program Manager
Gürcan Gülen, gurcan.gulen@beg.utexas.edu, (U.S.) 713-654-5404
Laura Martinez, laura.martinez@beg.utexas.edu, (U.S.) 713-654-5400
www.beg.utexas.edu/energyecon energyecon@beg.utexas.edu

Center for Integrated Seismicity Research

Mission

The Center for Integrated Seismicity Research (CISR) at The University of Texas at Austin is a multidisciplinary, intercollegiate research consortium managed by the Bureau of Economic Geology. CISR—together with TexNet and its State-funded network of seismometers across Texas—is focused on the integrated study of seismicity within the State of Texas and potential applications beyond. CISR research is designed to understand the subsurface processes that may influence seismicity, quantify and reduce risk to the citizens and infrastructure of Texas, and improve standards of practice to mitigate seismicity that may stem from industrial activity.

Goals

CISR will conduct fundamental and applied research to better understand naturally occurring and potentially induced seismicity and the associated risks, and to discern strategies for communicating with stakeholders and responding to public concerns regarding seismicity.

Scope

Seismology: Seismology research will include detailed spatial and temporal earthquake observations that will provide rich datasets for investigating the physics of faulting—essential to other components of CISR.

Geologic Characterization and Seismicity Analysis: Geologic and subsurface conditions influence the occurrence of natural and potentially induced earthquakes, and characterizing these conditions allows for a regional assessment of the potential for earthquakes. Integrating these data will inform geotechnical modeling and seismicity-potential analysis.

Geomechanics and Reservoir Engineering: Key to CISR research is an understanding of the dynamic interaction of regional to local reservoir structure, in situ stress, fluid pressure and flow, and faulting. Geomechanical characterizations and simulations could constrain the conditions associated with fault reactivation and provide guidance as to where and how injection practices might be modified to reduce the potential for seismicity. Simulation will also guide instrument deployment and inform data-collection strategies.

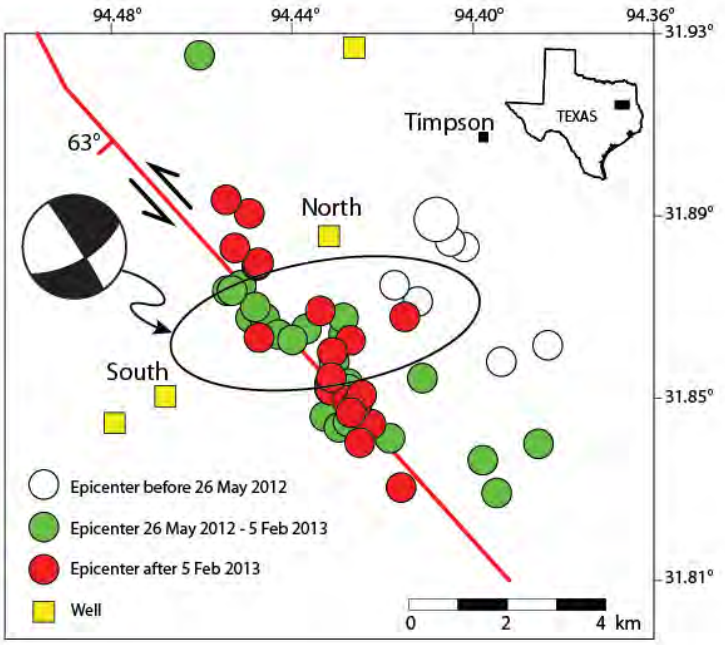
Seismic Hazard and Risk Assessment: Seismic hazard and risk assessment provides a rational approach to the evaluation of potential adverse effects from earthquakes. Research is required regarding the appropriate ground-shaking relationships for earthquakes in Texas, the seismic characterization of the near-surface geomaterials, and the vulnerability of infrastructure to low-seismicity regions.

Seismic Risk Communication: CISR will conduct research to understand stakeholder beliefs and values to better assess and predict emotional reactions to information on seismic risk, to identify key sources of resistance to scientific data about induced seismicity, and to develop a set of principles to predict stakeholder response to scientific information on natural and induced seismicity.

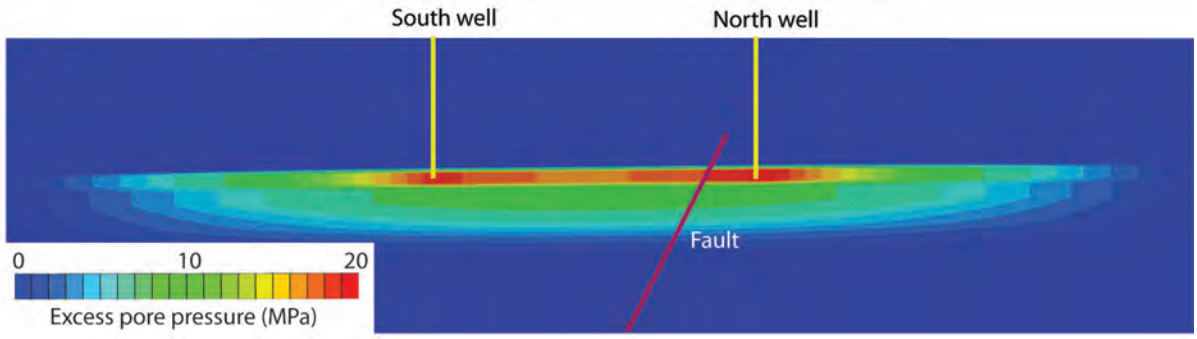
Organization

CISR will leverage data and analysis from the TexNet seismic monitoring program, which was funded in 2015 by the Texas Legislature to catalog Texas earthquakes. The annual investments made by industry partners will maximize the scope and applicability of CISR research.

CISR brings together distinguished researchers from UT-Austin's Bureau of Economic Geology; Institute for Geophysics; Department of Petroleum and Geosystems Engineering; Department of Civil, Architectural and Environmental Engineering; Department of Psychology; and School of Advertising and Public Relations. Researchers from the Department of Earth Sciences at Southern Methodist University and from Texas A&M University and Sam Houston State University will also contribute to the research effort.



Map of wells and epicenters for earthquake sequence near Timpson, East Texas (after Frohlich et al., 2014). Location of main Mw4.8 event (beach ball diagram) within elliptical region approximately defined by Mercalli intensity MMI VII area.



Excess pore pressure distribution adjacent to fault near Timpson, Texas, after 5 years of fluid injection into two wells (Fan et al., unpub. data).

Contact

Center for Integrated Seismicity Research (CISR)

Peter Hennings, Co-PI, peter.hennings@beg.utexas.edu, (U.S.) 512-471-0156
Ellen Rathje, Co-PI, e.rathje@mail.utexas.edu, (U.S.) 512-232-3683

TexNet

Alexandros Savvaidis, Project Manager, alexandros.savvaidis@beg.utexas.edu, (U.S.) 512-475-9549

www.beg.utexas.edu

Deep Reservoir Quality

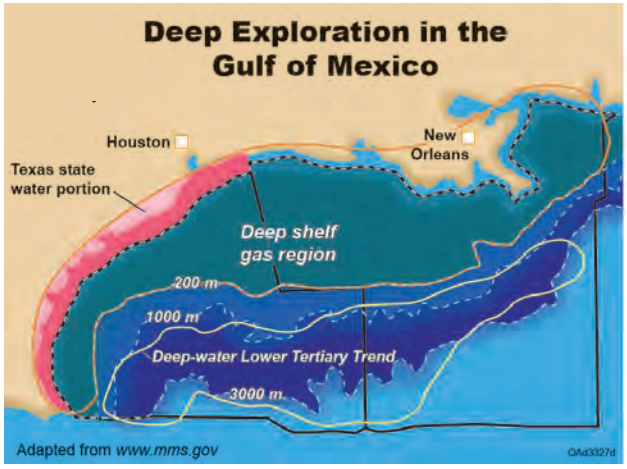
Gulf of Mexico Sandstones

Objective

This project provides concepts and data that can be used to forecast reservoir quality, reservoir architecture, and associated risk factors when drilling deep to ultradeep (15,000–35,000 ft) sandstone targets beneath the Gulf of Mexico (GOM) shelf and deep water. The study adds valuable updip regional knowledge for companies focused on downdip deep-water exploration.

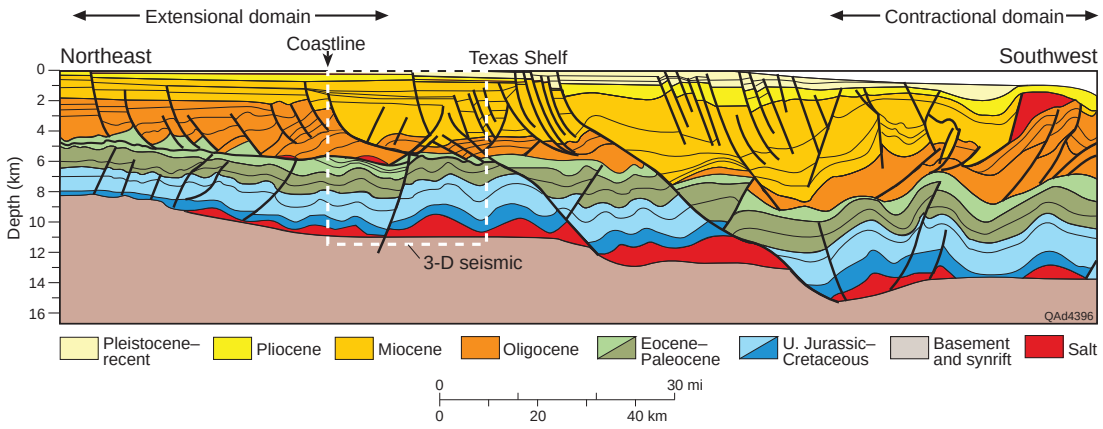
Research

In January 2014, we began a study of Upper Jurassic Cotton Valley and Smackover sandstones in the northeastern GOM. We also continue to investigate reservoir quality in lower Tertiary reservoirs by studying onshore Wilcox sandstones from Zapata County, near the Texas–Mexico border. We will assess regional trends in sandstone composition, diagenesis, pore types, and reservoir quality to evaluate reservoir potential in the deep-shelf play and deep-water GOM. Samples will be placed into a sequence-stratigraphic systems tract framework so that the influence of stratigraphic setting on texture, grain size, detrital mineral composition, and diagenesis can be evaluated.



Approach

The greatest unknown and most critical risk factor for deep to ultradeep exploration is reservoir quality. To improve reservoir-quality forecasting for deep Cotton Valley, Smackover, and Wilcox reservoirs, we will conduct regional studies using data from onshore wells in Texas, Louisiana, and Mississippi. These multidisciplinary studies, which are conducted by a team of experienced geoscientists, include (1) petrographic analysis of rock samples, (2) statistical analysis of porosity/permeability relationships to controlling parameters, (3) burial-history modeling of key wells, and (4) interpretation of sequence-stratigraphic systems tract framework.



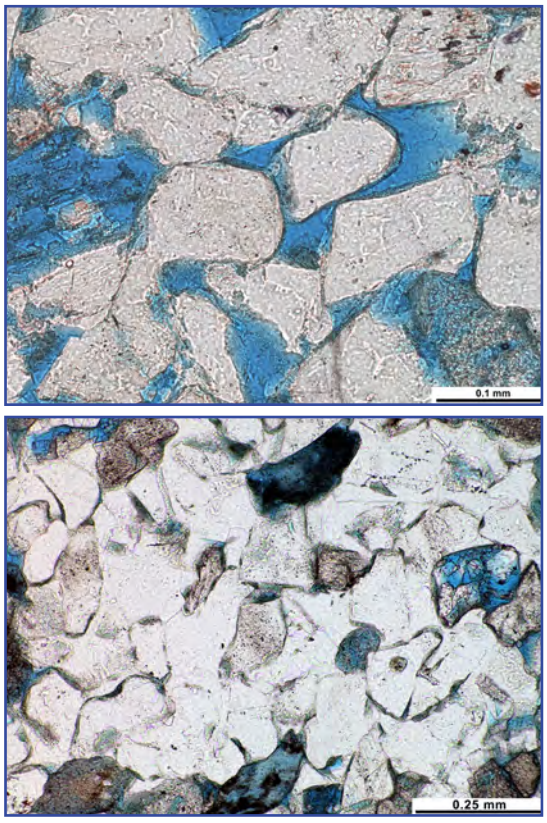
General stratigraphic and structural architecture of the Texas shelf (modified from Peel et al., 1995). The project is improving understanding of deep-play potential.

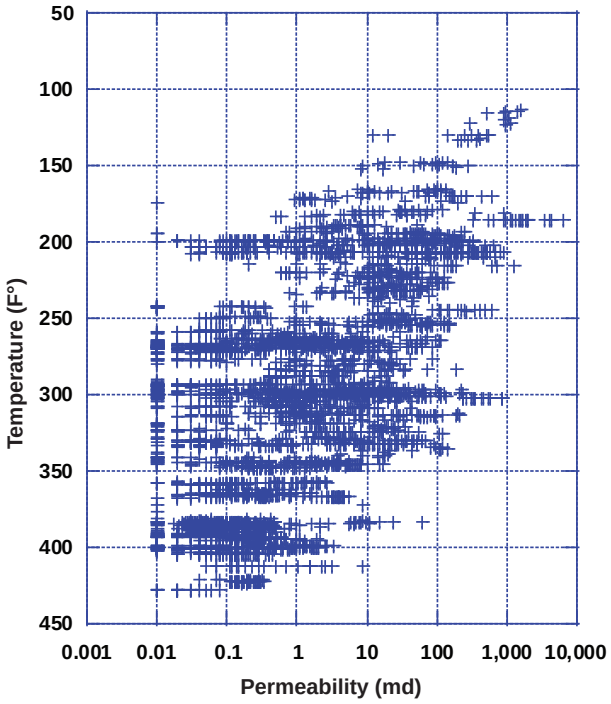
Products

Research results are distributed to member companies each year at a project-review meeting and in deliverables posted online, with a final written report provided at the end of the study. Products include:

- Core descriptions of major Cotton Valley, Smackover, and South Texas Wilcox cores, with sequence-stratigraphic interpretation
- Databases of Cotton Valley, Smackover, and Wilcox sandstone mineralogy
- Core-analysis porosity and permeability data
- Analysis of reservoir-quality trends versus depth and temperature
- Databases of sandstone porosity and permeability organized by depth, temperature, and pressure in a web-based search system
- Annual project meeting to convey research results

Results of previous studies of stratigraphic/structural architecture and sandstone reservoir quality of deep Tertiary reservoirs and Upper Cretaceous Tuscaloosa/Woodbine reservoirs along the Texas and Louisiana Gulf Coast are available for purchase.





Contact

Shirley P. Dutton, shirley.dutton@beg.utexas.edu, (U.S.) 512-471-0329
www.beg.utexas.edu/drq

Exploration Geophysics Laboratory

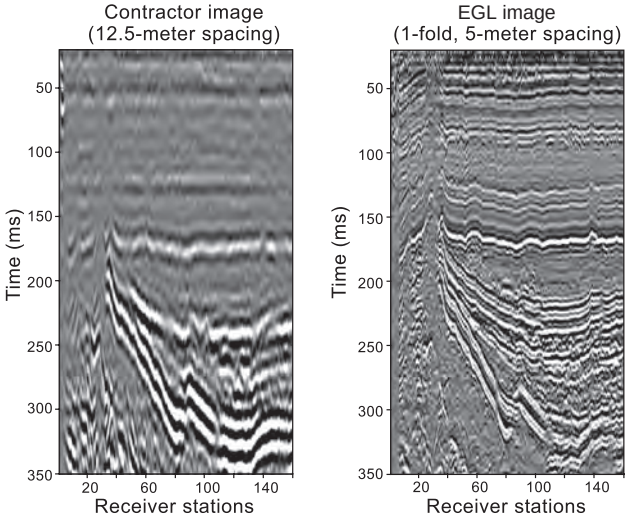
Multicomponent Seismic Research

Mission

Much of the geophysical research at the Bureau concentrates on developing multicomponent seismic technology that can be used to better characterize geologic systems. We focus on design of vector seismic sources, optimization of multicomponent data-acquisition and data-processing procedures, and unified interpretation of P- and S-wave images. The research is organized around the Exploration Geophysics Laboratory (EGL), an alliance of scientists from the Bureau and a consortium of industry sponsors. The EGL, established in 1997, develops seismic vector-wavefield technology for improved reservoir characterization and prospect evaluation and applies these technologies across both onshore and offshore prospects.

Impact

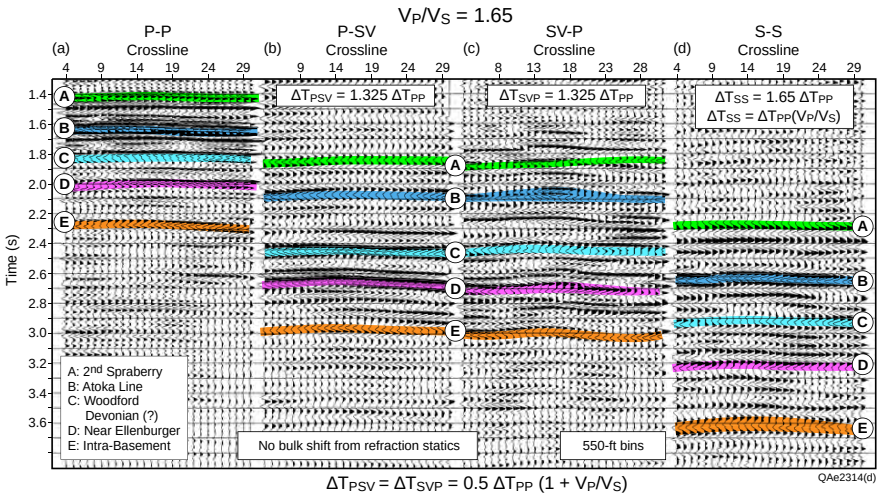
During the past several decades, the hydrocarbon exploration industry has relied on the P-wave component of the seismic wavefield for prospect development. However, each of the other modes of the full-elastic wavefield (SH-SH, SV-SV, P-SV, SV-P, fast-S, and slow-S) provides additional rock and fluid information. When all modes are acquired, processed, and interpreted, seismic-based geologic information increases significantly.



Comparison of deep-water, near-seafloor P-P images

Challenge

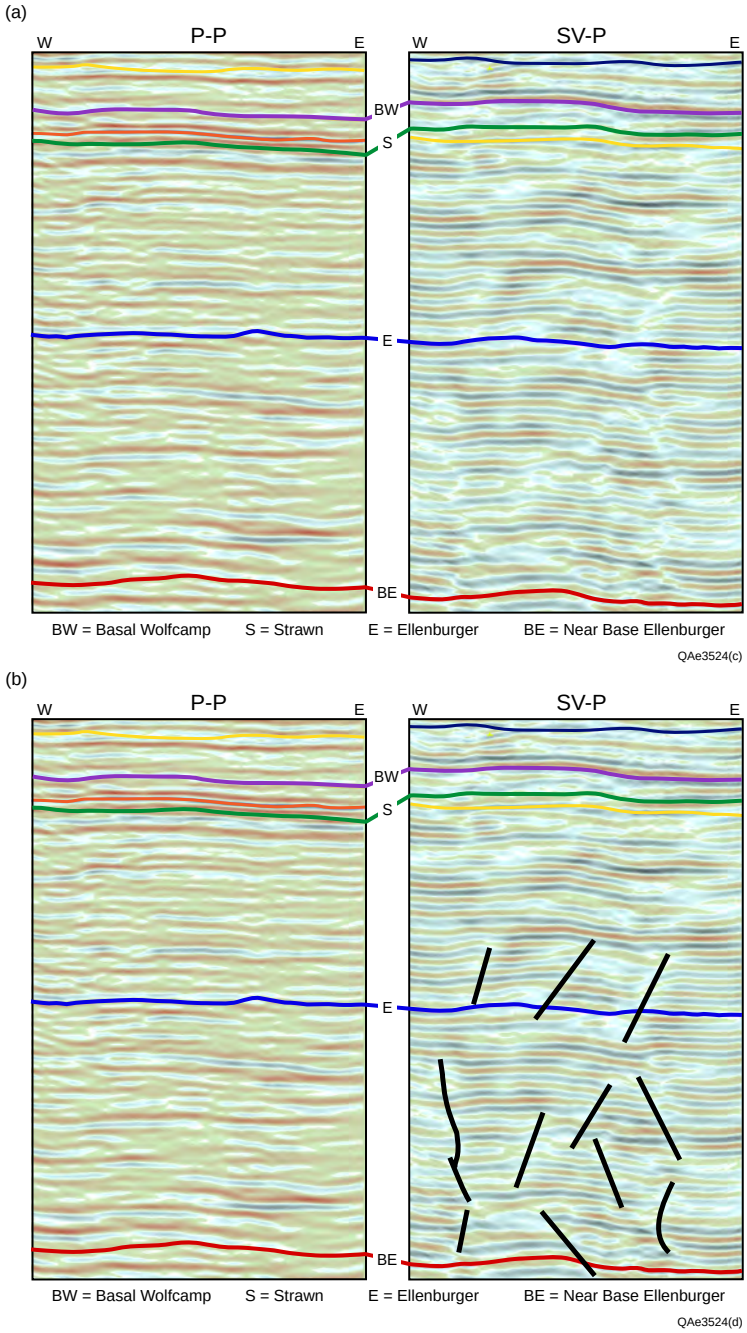
The traditional view is that full-elastic wavefield data (P-P mode plus fast and slow S-S, P-SV, and SV-P modes) can be acquired only if orthogonal XYZ receivers and orthogonal XYZ source displacements are utilized. EGL has developed technology that eliminates the three XYZ sources and captures full-elastic wavefield data with only P-wave (Z displacement) sources. This approach reduces data acquisition cost by 3X. This EGL technology also extracts P-P and SV-P data from only vertical-geophone data. This concept allows S-wave images to be extracted from legacy P-wave data already stored in seismic data libraries.



Full-elastic wavefield data showing the Wolfberry section in the Midland Basin. These images were created from 12-year old legacy data recorded with 3C geophones. All data were generated by a P-wave source (an array of 3 vertical vibrators). (a) Traditional P-P image. (b) Traditional P-SV image. (c) EGL's new SV-P image constructed from legacy vertical-geophone data. Note the equivalence to the P-SV image. (d) EGL's S-S image constructed from horizontal-geophone data. Images (c) and (d) illustrate that S-wave reflection seismology can be practiced with P-wave sources.

Value

EGL has found that in many instances in which P-wave seismic data do not image a particular target across a prospect area, one of the other elastic wave modes (SH-SH, SV-SV, or P-SV) provides the geological information needed. Which wave mode provides the desired rock and fluid information and/or reveals the proper sequence and structure for the area varies from site to site. EGL experience and know-how can be critical assets to operators who need optimal seismic evaluation of complex reservoir systems.



P-P and SV-P images extending across a deep carbonate unit where karst activity has produced a network of flow paths via small-scale faulting. (a) No interpretation imposed on the data. (b) Images with several interpreted karst features. Karst effects cannot be seen in the P-P image but are obvious in the SV-P image. These data illustrate why S-wave data are needed to ensure that sealing units above critical reservoirs have no embedded subtle faults or fracture systems that allow leakage. This S-wave image was created from legacy P-wave data recorded with vertical geophones.

Contact

Dr. Bob Hardage, bob.hardage@beg.utexas.edu, (U.S.) 512-471-0300
www.beg.utexas.edu/egl

Fracture Research and Application Consortium

Mission

Natural fracture research at The University of Texas at Austin seeks fundamental understanding of fractures and fracture processes with the aim of finding new geological, geophysical, and engineering methods to explain and successfully predict, characterize, and simulate reservoir-scale structures.

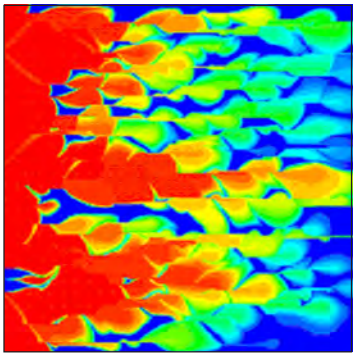
The purpose of this research is both fundamental and practical—to improve prediction and diagnosis of natural-fracture attributes in hydrocarbon reservoirs and accurately simulate their influence on production. Research is organized around the Fracture Research and Application Consortium (FRAC), an alliance of scientists from BEG and the departments of Petroleum and Geosystems Engineering and Geological Sciences, together with scientists from member companies. Student participation is an important part of our program. Many students find placement with member companies.

BEG (Bureau of Economic Geology)
PGE (Department of Petroleum and Geosystems Engineering)
DGS (Department of Geological Sciences)

Impact

More accurate prediction and characterization of fractures hold great potential for improving production by increasing the success and efficiency of exploration and recovery processes. New analytical methods will lead to more realistic characterization and prediction of fractured and faulted hydrocarbon-bearing carbonate, mudstone, and sandstone reservoir rocks. These methods produce data that can enhance well-test and seismic interpretations and that can readily be used in reservoir simulators. We are developing new and more reliable and efficient methods to predict hydraulic-fracture propagation in naturally fractured and other unconventional reservoirs.

Flow simulation.



"Joints" software for fracture modeling and permeability estimation.

Challenge

Many faults and fractures are difficult or impossible to characterize adequately using currently available technology. Fractures have been intractable to effective description and interpretation, posing serious challenges to exploration and development, as well as to accurate reservoir simulation and reservoir management. Our approach is helping to overcome the limitations of current methods.

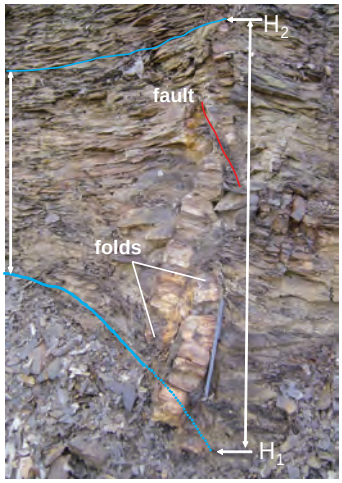
Scope

Results are germane to exploration and production. Our research includes measurement, interpretation, prediction, and simulation of fractures in carbonate rocks, mudstones, and sandstones to

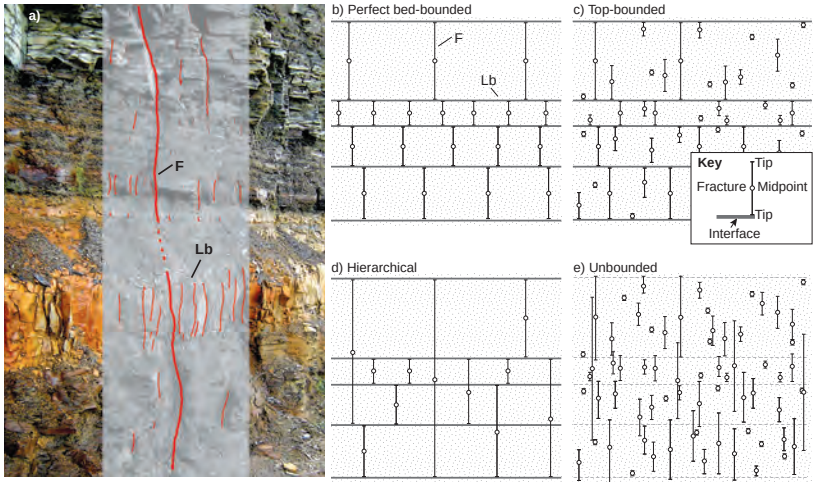
- Create and test new methods of measuring attributes of reservoir-scale fractures, particularly as fluid conduits and barriers
- Understand and predict the interaction of natural and hydraulic fractures
- Measure attributes at the reservoir scale through rigorous mathematical techniques and help build accurate and useful 3D models for the interwell region (members have exclusive access to our software)
- Develop the capability to accurately predict reservoir-scale flow using geomechanical, structural, diagenetic, and linked geomechanical/diagenetic models
- Improve the usefulness of seismic response as an indicator of reservoir-scale structure by providing methods of calibrating and verifying seismic fracture-detection methods
- Design new ways to incorporate geological and geophysical information into reservoir simulation and verify the accuracy of the simulation

Training in techniques, software, and our workflow is a benefit of membership.

Participants examine fractures in tight gas sandstones in the Canadian Foothills; FRAC field trip, fall 2013.



Quartz/dolomite/bitumen–filled fracture compacted by folding and faulting; the H1–H2 compacted fracture height is 70 cm. Blocher Member, New Albany Shale, Kentucky.



(a) Fracture-height patterns in New Albany shale roadcut with hierarchical fracture traces, eastern Kentucky. Some fracture traces cut multiple beds (F). Others are bed bounded (Lb = bed boundary). (b–e) Fracture-height classification categories from Hooker et al. (2013).

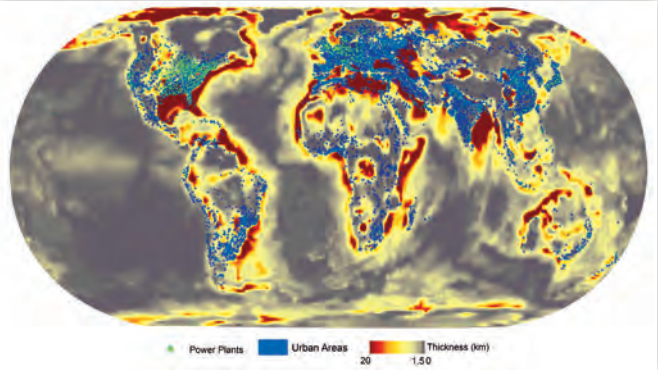
Contact

Dr. Stephen E. Laubach, steve.laubach@beg.utexas.edu, (U.S.) 512-471-6303
Dr. Julia F. W. Gale, julia.gale@beg.utexas.edu, (U.S.) 512-232-7957
Dr. Richard A. Schultz, richard.schultz@austin.utexas.edu
www.beg.utexas.edu/frac

Gulf Coast Carbon Center

Mission

Carbon dioxide, produced by the combustion of fossil fuels, exceeds the global assimilative capacity and may result in negative impacts on the ocean and climate. The Gulf Coast Carbon Center (GCCC) seeks to impact global levels of atmospheric greenhouse-gas emissions.



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

Impact

Since 1998, the GCCC has been a leader in research that facilitates a proactive response by energy-related businesses to reduce atmospheric release of CO_2. The GCCC has led five major field research projects to develop effective technologies to monitor retention of CO_2 in the subsurface and is working with teams to develop more projects.

In addition, the GCCC has led diverse topical projects, including storage capacity, Enhanced Oil Recovery (EOR) screening and economic assessments, risk of leakage to water resources, assessment of pressure, and whole system integration. The GCCC also hosts STORE, a training and education effort.

Research Approaches

The GCCC's approaches to research include:

- Conducting and participating in next-stage field studies of geologic CO_2 sequestration in the deep subsurface, both onshore and offshore
- Measuring and monitoring the retention of CO_2 in the deep subsurface through the use of field studies coupled with models of risk, capacity, and economic viability
- Developing and distributing information to all stakeholders, including educating the public about benefits and risks of geologic CO_2 sequestration
- Collaborating with leading regional, U.S., and international researchers
- Enabling the private sector to develop an economically viable CO_2 sequestration industry

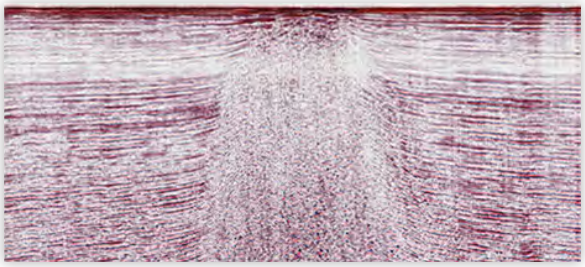
Geographic Area

Sources. Refineries and chemical plants along the Texas, Mississippi, and Louisiana Gulf Coast produce CO_2 streams that are being tapped to start the sequestration process through enhanced oil recovery (EOR). These large sources of CO_2 can be used for some processes, but storage capacity is needed to reduce atmosphere release.

Sinks. The region's depleting hydrocarbon fields provide large and well-known reservoir volumes for enhanced oil production and CO_2 storage, which are now underway. New energy resources in residual oil zones require CO_2 for production. Additional volumes onshore and offshore demonstrate that storage is feasible at needed scale and durations.

Field Sequestration Experiments

The GCCC has led an aggressive DOE-sponsored field program with substantial industry partnerships to test the performance of monitoring technologies under real-world conditions.



Surveys of potential storage sites in the Gulf of Mexico are characterized using the novel P-cable system that provides high-density seismic information on overburden.

Major Ongoing Projects

Texas Offshore Miocene Capacity Study. A regional study of offshore state-owned lands acquires unique, high-resolution 3D seismic datasets and incorporates commercial 3D seismic with extensive well data and limited, valuable rock data to provide improved understanding of offshore sequestration opportunities near significant CO_2 sources.

SECARB Stacked Storage. Monitoring of 5 million metric tons of CO_2 storage at a commercial EOR site in Mississippi, including a novel, multiphysics monitoring array in two deep observation wells with participation by several DOE national laboratories and industry.

NRG Energy Clean Coal Power Initiative and Denbury Hastings Project Monitoring. Design and execution of monitoring plan for CO_2 storage at two commercial-scale projects.

Notable Completed Projects

Frio Brine Test. This worldwide first closely monitored injection experiment documented the validity of models to predict the fate of injected CO_2.

West Texas Study. Long-term injection at SACROC field, Curry County, showed no impacts from CO_2 in groundwater quality after more than 35 years of injection.

GCCC Goals

Through combined industry and academic funding we are:

- training the next generation of geotechnical experts in CO_2 storage technologies;
- providing rigorous technical information to diverse stakeholders; and
- investing in key research to strengthen the confidence of industries moving toward large-scale deployment of carbon capture and storage.

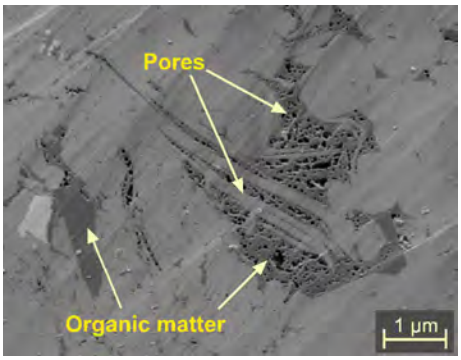
Contact

Dr. Susan D. Hovorka, susan.hovorka@beg.utexas.edu, (U.S.) 512-471-4863
www.gulfcoastcarbon.org www.storeco2now.com

Mudrock Systems Research Laboratory

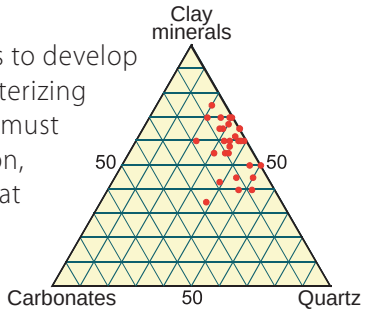
Mission

The Bureau's Mudrock Systems Research Laboratory (MSRL) program brings together a broad spectrum of research expertise necessary to confront the complicated, multidisciplinary questions that are key to a better understanding of mudrock systems. The goal of the program is to integrate observations and data from all scales, ranging from nanoscale pores to regional basin setting, from element maps to borehole and 3D geophysics, from fractures to flow modeling, and from clay diagenesis to sequence stratigraphy. Only through this kind of integrated approach can the multiscalar heterogeneities of mudrocks be effectively characterized and models leading to better predictions of reservoir quality be developed.



Challenge and Impact

Mudrock systems in many ways constitute a last frontier in sedimentological research. Despite their abundance in the Earth's crust, these rocks are much less well understood than other systems. The current explosion of interest in these rocks stems from their potential as oil and gas reservoirs. However, few, if any, 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 required or commonly utilized in other sedimentary rock systems.



Key Areas of Research

- FE-SEM and atomic force microscopy of Ar ion–milled surfaces to reveal pore architecture
- Analysis of mechanical properties of mudrocks in time and space
- Application of element and isotope geochemistry to better define facies and their continuity
- Delineation and modeling of regional and local trends in depositional and diagenetic facies distribution
- Development of more accurate ways to determine porosity, permeability, and model flow
- Critical appraisal of conventional methods of mudrock analysis techniques, history, thermal maturation, and rock-attribute development
- Calibration and interpretation of borehole geophysical data

Research Methods and Tools

- Nanopore analysis: field-emission SEM microscopy, Ar-ion milling, N^2 adsorption, and X-ray CT
- Elemental and mineralogical composition: field-emission SEM, cathodoluminescence, and light microscopy; XRD, ICP-MS, XRF, and stable-isotope analysis
- Fluid-flow research: atomic-force microscopy
- Organic matter and hydrocarbon analysis: Rock Eval, GC, vitrinite reflectance, and kerogen analysis
- Attribute distribution: integrated outcrop, core, and geophysical analysis

Project Structure

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

Systems Being Studied

Paleozoic

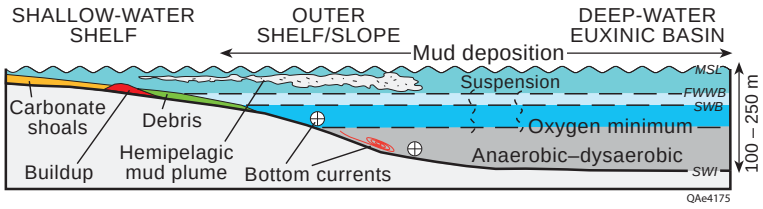
- Atoka
- Bakken
- Barnett
- Bone Spring
- Cline
- Duvernay
- Marcellus
- New Albany
- Niobrara
- Smithwick
- Spraberry/Dean
- Wolfcamp
- "WolfBerry"
- Woodford
- Yanchang
- Zechstein Permian

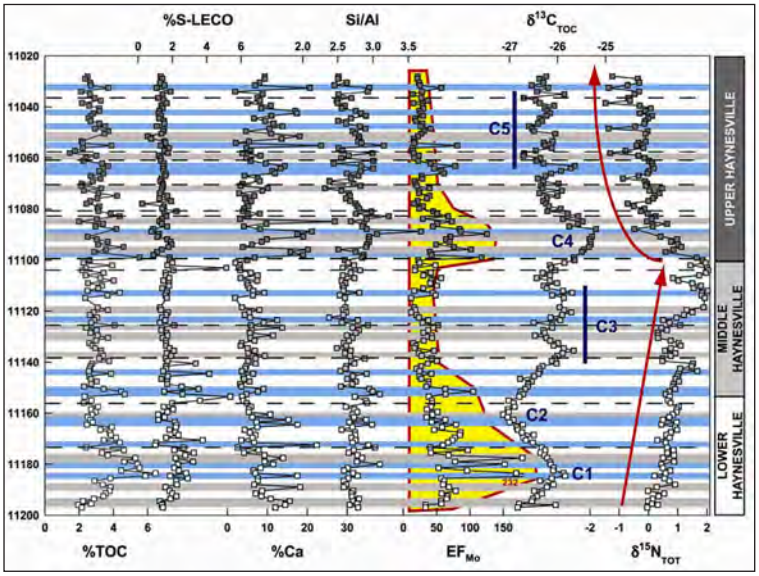
Mesozoic

- Eagle Ford
- Haynesville
- Pearsall
- Tuscaloosa

Cenozoic/Recent

- Frio
- Wilcox
- Nankai accretionary prism





Contact

Steve Ruppel, stephen.ruppel@beg.utexas.edu, (U.S.) 512-471-2965
Bob Loucks, bob.loucks@beg.utexas.edu, (U.S.) 512-471-0366
www.beg.utexas.edu/msrl

Quantitative Clastics Laboratory

Mission

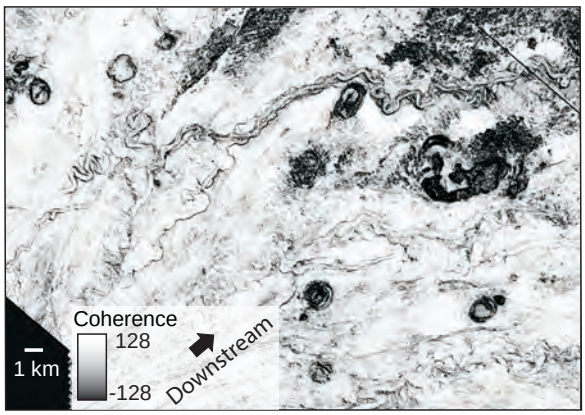
The mission of the Quantitative Clastics Laboratory (QCL) is to carry out integrated geologic studies at multiple scales to develop predictive models for processes and controls on sediment transport and the stratigraphic evolution of depositional systems for our industry members.

Goals

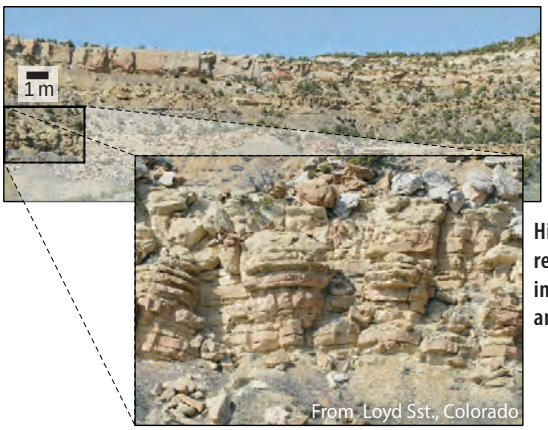
QCL researchers aim to provide industry members quantitative data on clastic depositional system architecture for the characterization of connectivity and heterogeneity of reservoirs. They also aim to develop concepts for the prediction of stratigraphic architecture and controls on the evolution of fluvial, shallow-marine, and deep-water depositional systems for evaluation of reservoir presence and quality in frontier basins.

Approach

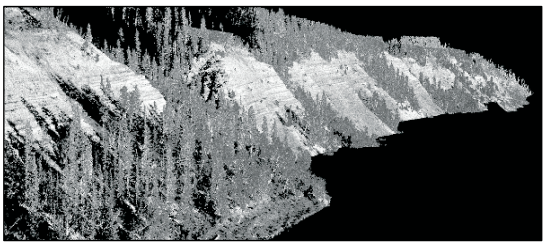
QCL researchers leverage the broad, world-class expertise of the Jackson School of Geosciences—including collaborations with groups specializing in structural geology, Texas and Gulf of Mexico depositional syntheses, seismic interpretation, and burgeoning technology in geochronology and thermochronology—to address key challenges in the exploration and development of natural resources: the evaluation of reservoir presence and quality in data-limited frontier basins and the characterization of connectivity and heterogeneity of reservoirs. The QCL has unique clastic research consortia access to industry subsurface data, including global seismic-reflection datasets and BEG core repositories. The project team uses subsurface, outcrop, Earth surface, and marine geology datasets to evaluate predictive, source-to-sink relationships between hinterland, fluvial, shoreline, shelf, slope, and deep-basin environments. Researchers develop models of stratigraphic evolution and evaluate the impact of facies modeling on reservoir performance. Active research focus areas are prospective sedimentary basins around the world.



Seismic coherence image of submarine channel deposits, mud diapirs, and mass transport deposits, offshore Trinidad



High-resolution imagery and lidar

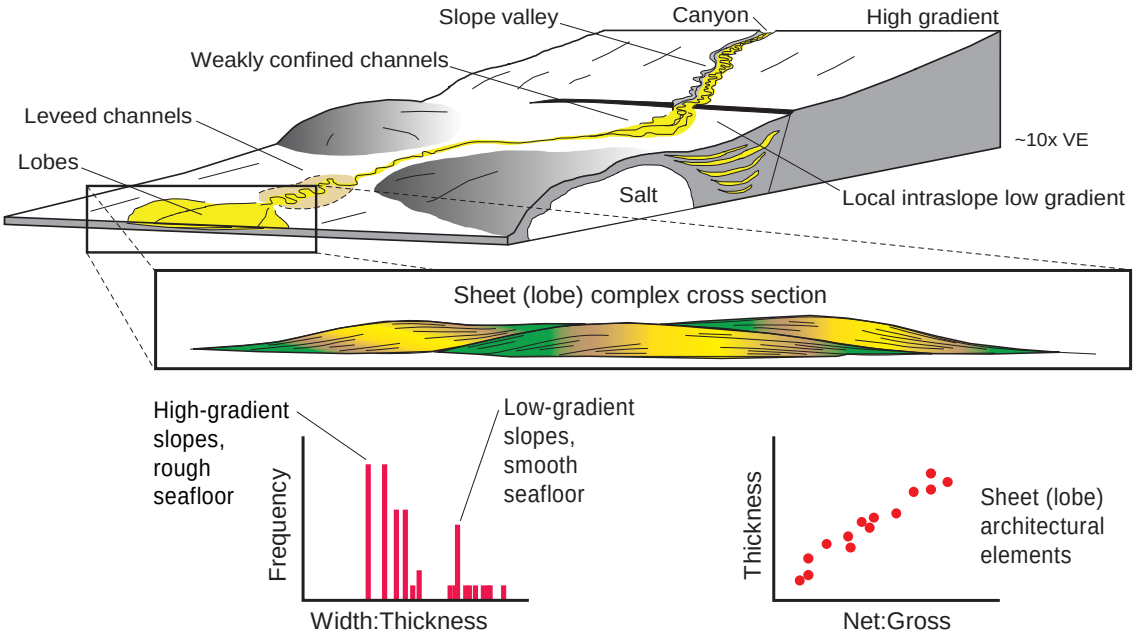


1800-m-long lidar survey of the McMurray Formation outcrops along the Athabasca River, Canada

QCL researchers annually host multiple meetings and workshops and pursue regular face-to-face interaction and collaboration with industry personnel. The QCL offers industry members unique access to expertise of the Jackson School of Geosciences, industry subsurface data, investigations of multiple scales of depositional environments and their interconnections, and an evolving quantitative database on clastic depositional systems architecture.

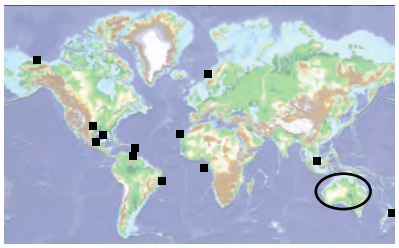
Reservoir Analog Architecture and Dimensional Database

The Reservoir Analog Architecture and Dimensional Database is being improved to provide an intuitive, searchable source of quantitative information on reservoir architecture to our industry members. We aim to provide quantitative distributions, not just ranges, of reservoir architectural elements in a variety of settings. We have established search functionality for legacy QCL data and are organizing the database according to a simplified scheme of architectural elements of fluvial, shallow-marine, and deep-water depositional elements. This organic database is continually improving: through 2016, we are adding thousands of new data points on sediment delivery to continental margins and the grain size and geometry of deep-water depositional systems and reservoir elements.

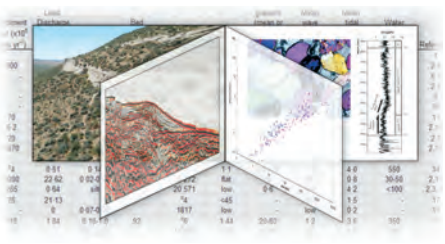


BEG core repository

QCL subsurface data



QCL database



Terms

- Each year's research calendar begins January 1 and runs through December 31.
- Multiple meetings, workshops, and face-to-face consultation with industry members are held annually.
- Website and database access is limited to active members; however, annual meeting presentation material, field-trip guides, and publications remain available to inactive members for membership years.

Contact

Jacob (Jake) Covault, jake.covault@beg.utexas.edu, (U.S.) 512-475-9506
www.beg.utexas.edu/indassoc/dm2

Reservoir Characterization Research Laboratory

Mission

Carbonate reservoir characterization at the Bureau of Economic Geology includes a multipronged approach of research and applied field studies. Carbonate research is concentrated within the Reservoir Characterization Research Laboratory (RCRL), an industry-supported consortium.

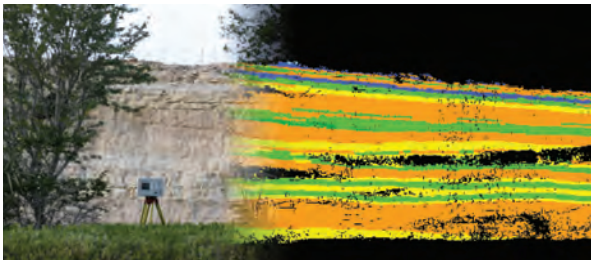
RCRL's mission is to use outcrop and subsurface geologic and petrophysical data from carbonate reservoir strata as the basis for developing new and integrated methodologies to better analyze and describe the 3D reservoir environment.

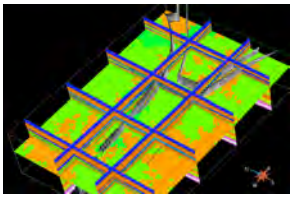
Challenge and Impact

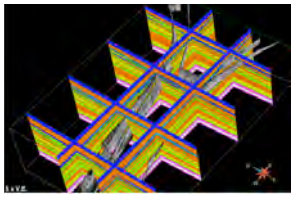
Methods of constructing 3D geocellular models of carbonate reservoirs that have realistic stratigraphic and petrophysical property distribution have been and continue to be the major challenge for the RCRL. Current research focuses on several principal areas:

1) Geological, petrophysical, and seismic characterization of non-matrix and fracture systems and integration of these data into fluid-flow models for predicting carbonate-reservoir performance

2) 3D modeling of carbonate reservoir outcrop analogs by integrating laser mapping, velocity measurements, and geostatistical modeling for guiding the building of subsurface models



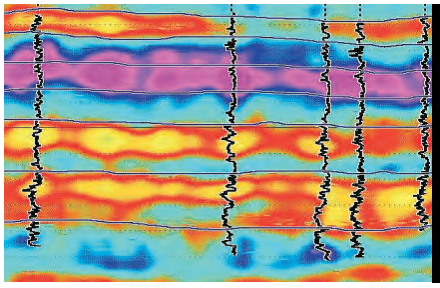


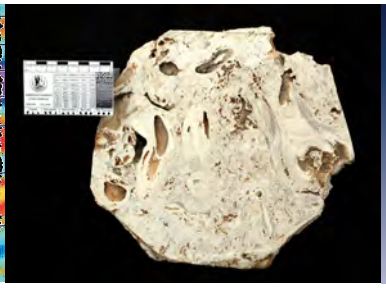


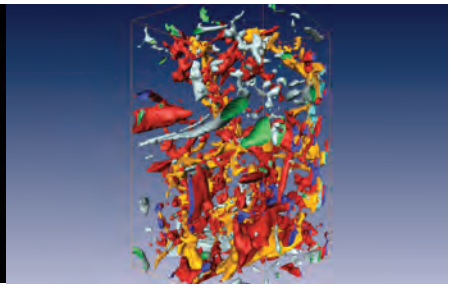
3) Understanding the origin and distribution of micropores in carbonates and their effect on petrophysical properties

Primary Areas of Research

- 3D modeling of geologic facies, petrophysical rock-fabric elements, and fractures within a sequence stratigraphic framework using outcrop and subsurface data
- Mapping, characterizing, and modeling of matrix and nonmatrix pore systems
- Seismic imaging and inversion of carbonate facies and pore systems
- Characterization of micropore networks

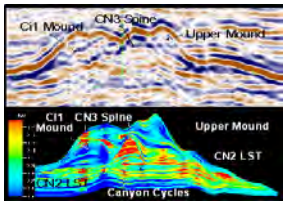


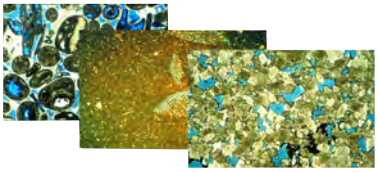


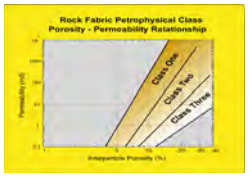


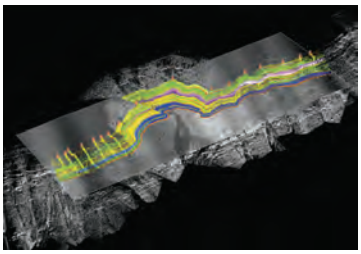
Key Insights

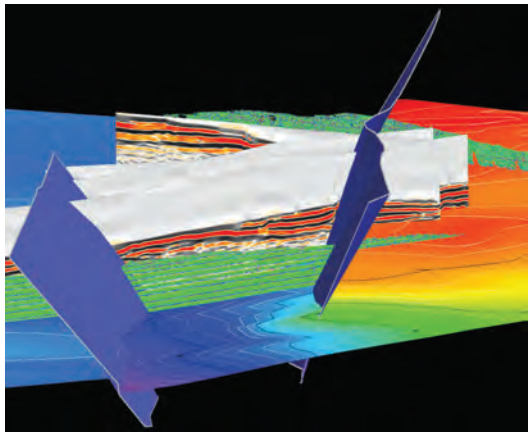
Fundamental approaches to the stratigraphic analysis of carbonate systems and their petrophysical and geostatistical characterization have been and continue to be the key insights from RCRL's research. A solid approach to modeling of stratigraphically dominated heterogeneity styles is now fairly robust, and methods and insights for modeling more complex matrix and non-matrix pores and fractured reservoirs are being investigated.











Dissolution-enhanced fractures at Canyon Lake Spillway, Texas.

Lidar image (left) and photograph (right) of Albian carbonates along Pecos River, Texas.

Contact

Bob Loucks, loucksb@beg.utexas.edu, (U.S.) 512-471-0366
Charlie Kerans, charles.kerans@beg.utexas.edu, (U.S.) 512-471-1368
www.beg.utexas.edu/rcrl

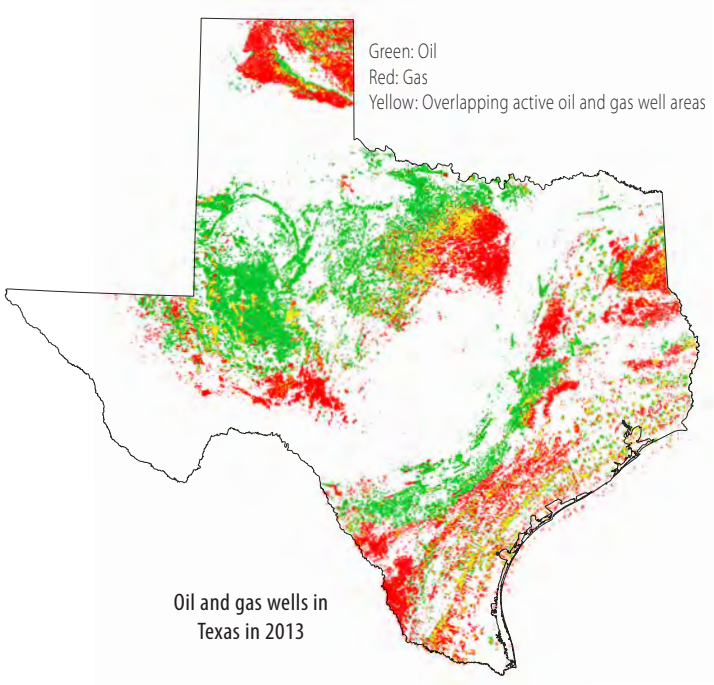
State of Texas
Advanced Oil and Gas Resource Recovery

Mission

The goal of the State of Texas Advanced Resource Recovery (STARR) program is to increase severance tax income from oil and gas production anywhere within the State of Texas. Researchers work with partners to develop reservoir characterization studies that lead to drilling of new wells, recompletion of old wells, and development of enhanced recovery programs. Regional studies of conventional and unconventional plays are also conducted to promote exploration of new targets.

Value

Since 1995, more than 50 fields or exploration areas in the state have undergone, or are currently undergoing, characterization and development by STARR researchers. In the 2012–2014 biennium, the STARR project added ~$141 million to State revenue from severance taxes from increased production.



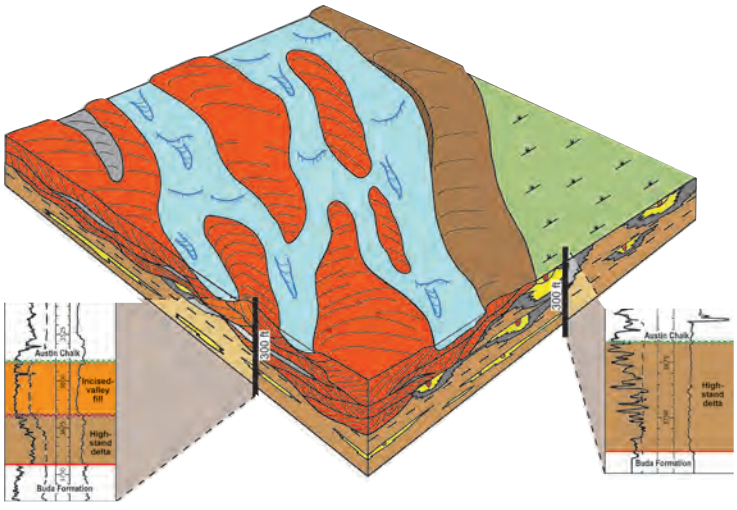
Oil and gas wells in Texas in 2013

Impact

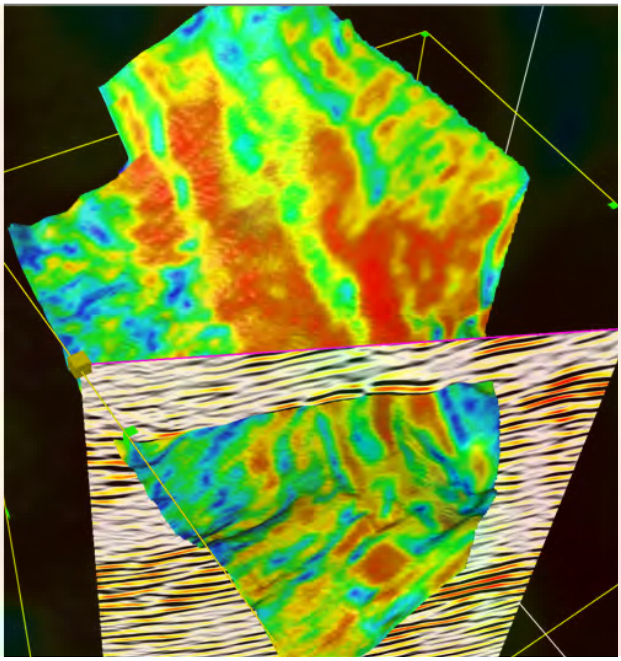
Texas leads the United States in oil production, accounting for more than 2.4 million barrels per day in 2013. Significant oil production comes from unconventional shale plays including the Eagle Ford and Wolfberry trends, which the STARR project has successfully characterized for the State of Texas.

Research Approach

Studies are based on integration of geophysical, geological, petrophysical, and engineering data. An advanced sequence stratigraphic approach helps define the stratigraphic architecture of each area and delineate reservoir types. We employ the latest technologies in reservoir characterization, including Landmark Graphics, SMT, Matlab, Petra, and Geolog interpretation software to analyze 3D seismic data, to model seismic attributes, and to petrophysically analyze and correlate wireline logs.



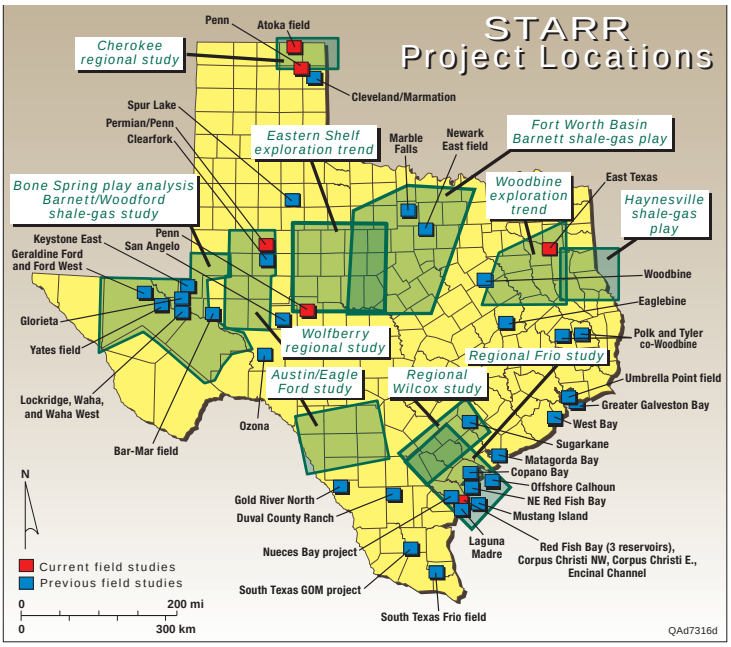
Woodbine incised-valley fill model in East Texas field



3D seismic display of seismic cross section and amplitude display showing potential slope fans in the lower Frio Formation

Participation

All Texas operators are invited to participate, at no cost, in project STARR, from which they can obtain expert technical advice in developing oil and gas fields. Project STARR gives priority to operators planning to drill in the near term, to those willing to share data and incidental costs, and to those operating on Texas State Lands. Any operators working on non–Texas State Lands are also welcome to participate.

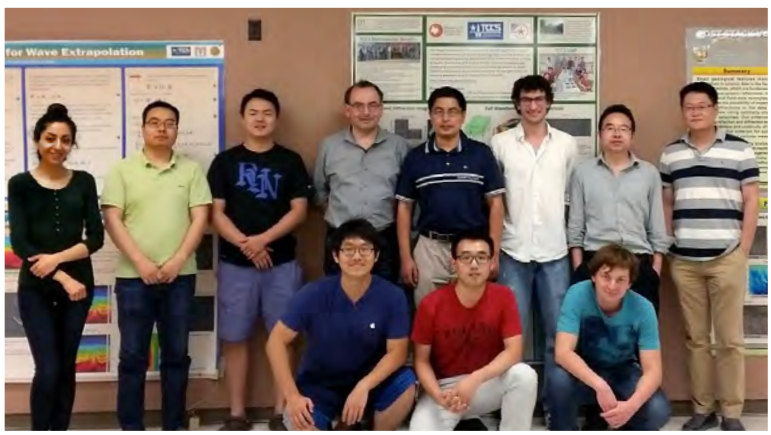


Contact

William Ambrose, william.ambrose@beg.utexas.edu, (U.S.) 512-471-0258
www.beg.utexas.edu/starr

Texas Consortium for Computational Seismology

TCCS is a collaboration between the Bureau of Economic Geology and the Institute for Computational Engineering and Sciences (ICES).



Mission

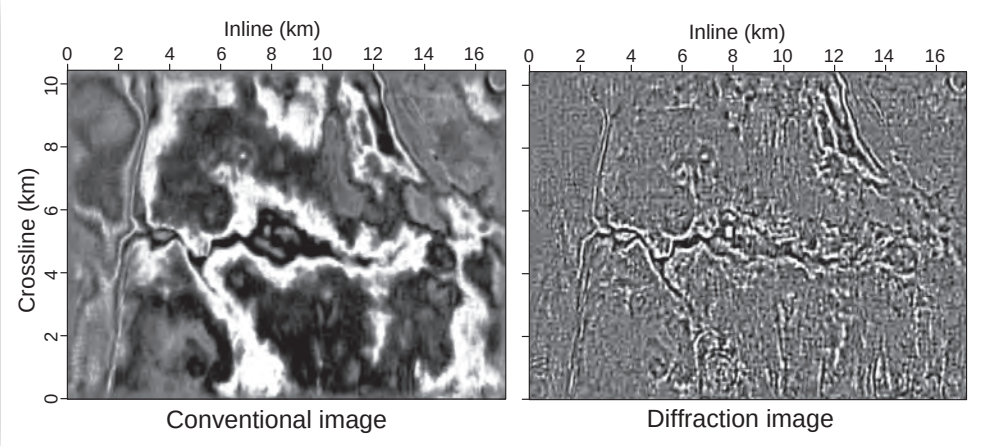
- To address the most important and challenging research problems in computational geophysics as experienced by the energy industry
- To educate the next generation of research geophysicists and computational scientists

Research Challenges

- Estimating seismic velocities by using full waveform information
- Identifying the most accurate and efficient seismic imaging algorithms while controlling the trade-off between accuracy and efficiency
- Increasing the resolution of seismic reservoir characterization
- Assisting the seismic interpreter by automating common interpretation and signal-processing tasks

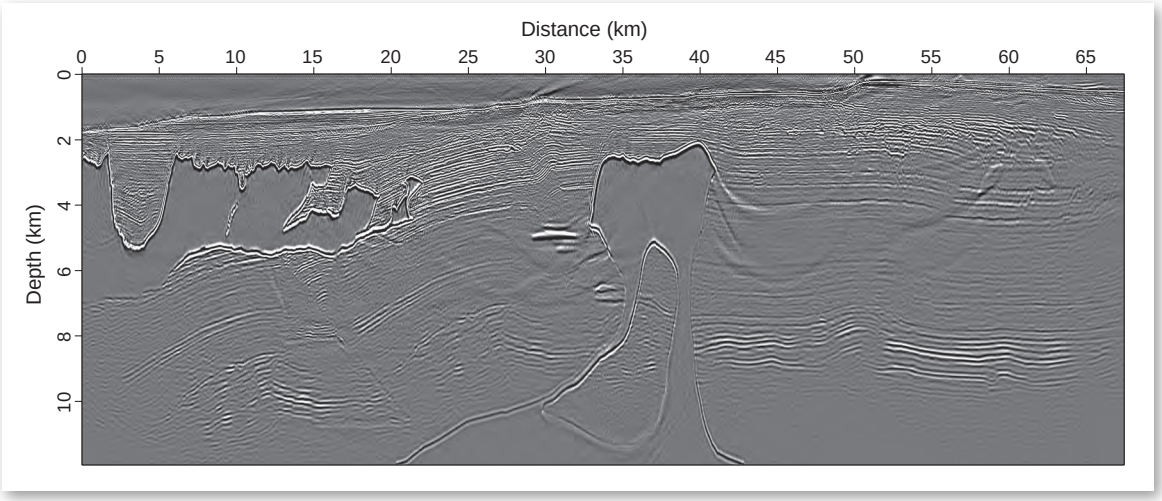
Reproducible Research

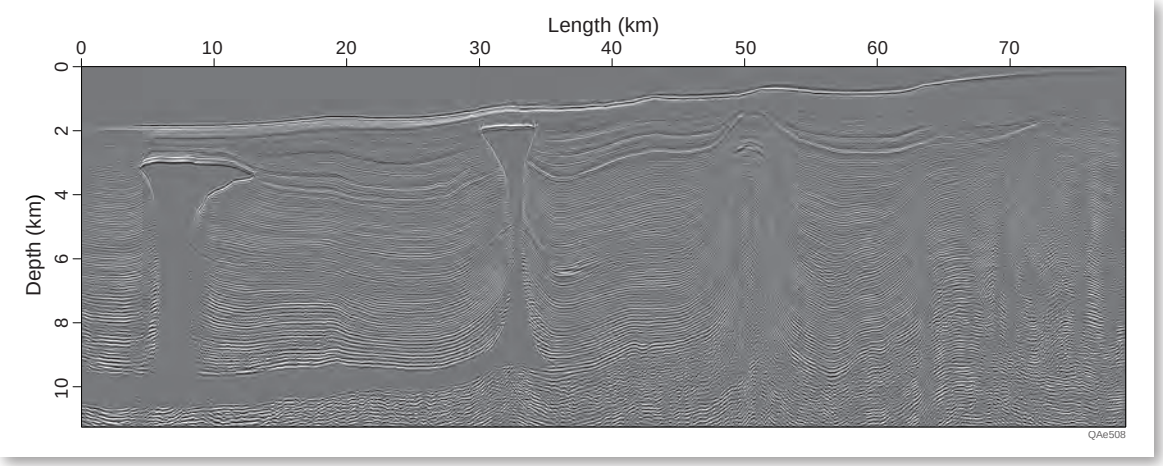
Our publications follow the discipline of reproducible research: the results of each computational experiment are supplied with open-source software code required for reproducing and verifying the experiment.



Examples of Focused Research Projects

- High-Resolution Imaging of the Barrolka Dataset Using Diffraction Attributes
- Characterization of Fractured Shale Reservoirs Using Anelliptic Parameters
- Phase Correction of Prestack Seismic Data Using Local Attributes
- Extracting Seismic Events by Predictive Painting and Time Warping
- Lowrank Reverse Time Migration for Subsalt Imaging
- High-Resolution Seismic Attributes for Fracture Characterization in Grosmont Formation
- Waveform Tomography with Cost Function in the Image Domain
- Multiazimuth Seismic Diffraction Imaging for Fracture Characterization in Low-Permeability Gas Formations
- Seismic Wave Focusing for Subsurface Imaging and Enhanced Oil Recovery





Contact

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

Tight Oil Resource Assessment

Challenge

The Permian Basin, the most prolific oil-producing basin in the United States, has yielded some 34 billion barrels of conventional oil since the 1930's. One respected operator reported that the estimated unconventional tight oil recoverable-resource potential in part of the basin (Midland subbasin) exceeds 75 billion barrels—more than twice the historical production of the entire Permian Basin and possibly representing the largest recoverable oil resource in the United States. Indeed, the future potential of the Permian Basin is enormous, yet no comprehensive analysis is available.

Mission

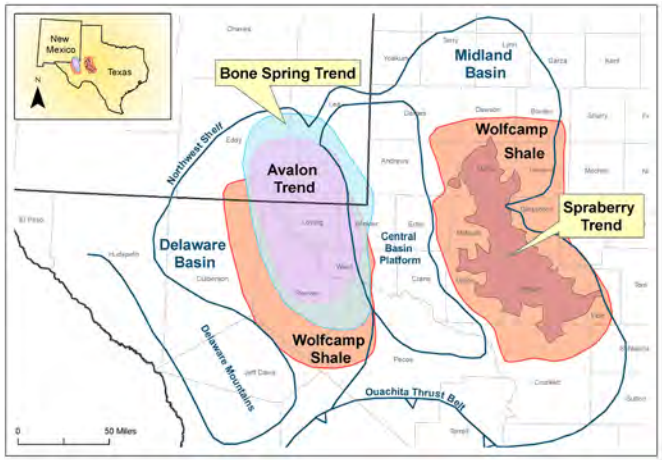
The Tight Oil Resource Assessment (TORA) project, based on the Permian Basin, will build on the exemplary research of the Bureau of Economic Geology's national shale play resource and production rate study to analyze the complex oil-rich source rocks of the Midland and Delaware Basins. TORA will adapt and improve the shale study's workflow to help predict ultimate hydrocarbon recoveries, economic viability, and playwide production rates. It will address main tight oil formations such as the Spraberry, Wolfcamp, Bone Spring, and Avalon in order to produce unbiased, comprehensive, and publicly available results.

Goals

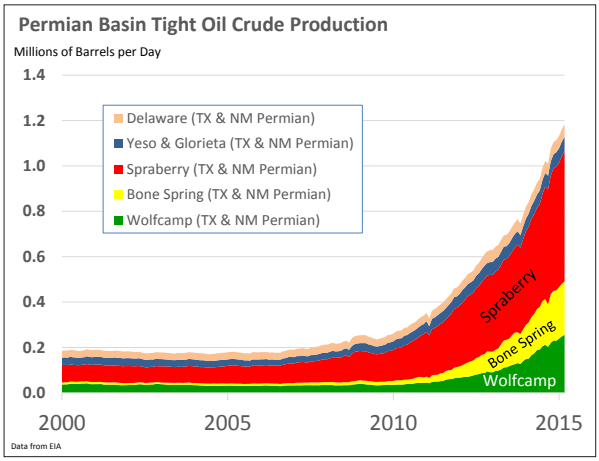
The TORA project will leverage funding allocated by the State of Texas (to assist operators in increasing their production) with annual investments by industry partners to maximize the scope of the research conducted on the abovementioned formations. The project will bring together an integrated, multidisciplinary team from across The University of Texas at Austin and beyond. A team of geologists, petroleum engineers, petrophysicists, economists, hydrologists, and GIS/database experts will employ a multifaceted approach to analyzing a wide variety of challenging subject areas, including the following:

- Geology and Petrophysics
- Reservoir Engineering
- Economics
- Water Resource Management

The resulting products will be the most comprehensive resource assessment yet performed on these formations, informing government, industry, and the general public of their hydrocarbon production potential and water resource impacts over the next several decades.



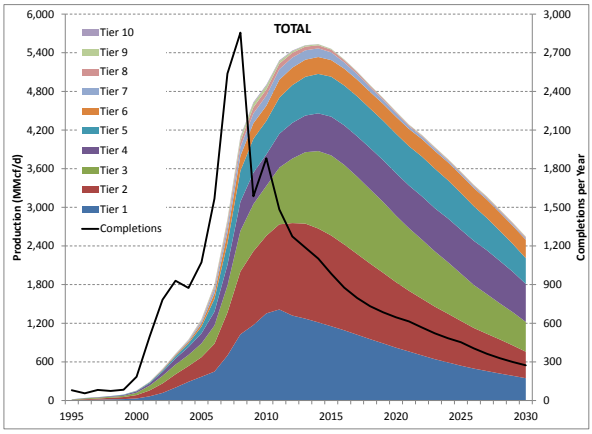
Permian Basin tight oil plays.



Permian Basin tight oil production 2000–2015.

Methods

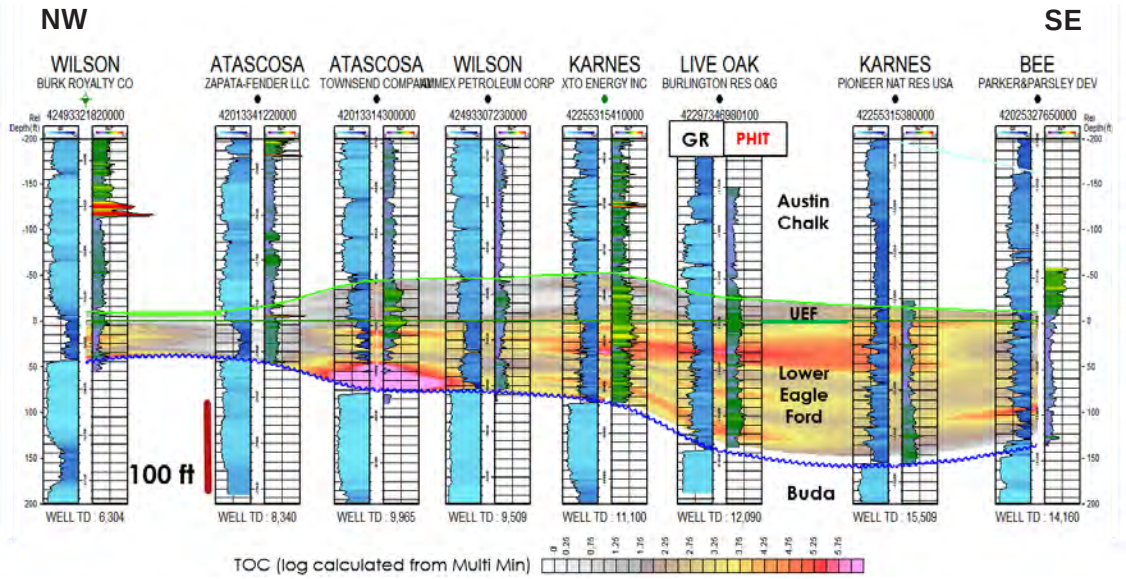
TORA employs a "bottom up" approach that starts with detailed geologic mapping and a well-by-well production analysis. Each productive interval is mapped for structure, thickness, porosity, saturation, and other geologic attributes from well logs and cores. Each existing well's production history is modeled and matched before projecting its future production. A production outlook is developed for each formation based on existing wells and future development locations, considering the full range of expected production outcomes per well, costs, incremental economics, pace of drilling, well attrition, lease accessibility, and logistics. Production outlooks will depend on economic considerations, including various price, cost, and technology-improvement scenarios. In turn, water resources utilized in drilling and production operations and/or produced from these formations will be thoroughly studied to determine full-cycle water volumes needed, likely sources and methods of disposition or re-use, and associated water-related costs.



A schematic illustrating production outlook for a specific price case.

Benefits

Industry partners will be invited to semiannual update meetings, receive annual reports, and have access to the TORA research team for informal interaction and consultation. Industry feedback and input will be vital to the direction and success of TORA research.



A schematic illustrating petrophysical interpretation of TOC.

Contact

Mark Walsh, Project Manager, mark.walsh@beg.utexas.edu, (U.S.) 512-471-6775
www.beg.utexas.edu

THE UNIVERSITY OF TEXAS AT AUSTIN
Bureau of Economic Geology
Jackson School of Geosciences
PO Box X, University Station
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