Research Consortia
Bureau of Economic Geology
The Bureau of Economic Geology (BEG) 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, geofluids, 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 BEG 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 BEG industrial consortia or the breadth of your company’s engagement with the Bureau, please contact Eric Potter, Associate Director, at eric.potter@beg.utexas.edu or by phone at 512-471-7090.
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 incredible 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.

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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 20 years have profoundly influenced 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
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

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Center for Energy Economics

Who We Are

Based within UT’s 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.

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 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
Sample Factors Impacting Gas Use for Power

- Demand-side response
- Large-scale electricity storage
- Decreasing price of oil
- CC for gas-fired plants
- Energy-security concerns
- Gas price < $6
- Gas price > $7
- GHG regulation
- Higher-demand growth
- Lower-demand growth
- Mercury (EPA MATS)
- Methane regulation
- More renewables
- Nuclear retirement
- Smart-grid deployment
- SOX & NOX (EPA CSAPR)
- Water scarcity

CEE Analytics and Modeling

- Frame of Reference
- Integrated Scenarios
  - Oil & gas: upstream, midstream economics, risk analysis
  - Power value chain: generation cost, risk analysis, power dispatch
- Oil & gas market dynamics: supply-demand, pricing
- Economic impacts

Energy webs: Trade-offs and policy/regulatory drivers

The Energy Web

- GHG (climate)
- Envt (air)
- Energy security
- Safety
- Reliability
- Market friendly

- Coal
- Natural gas
- LNG
- Nuclear
- Hydroelectric
- Solar, wind (grid-based)
- Solar, distributed

Our Geography and Reach

- Houston HQ
- New Era in Oil, Gas & Power Value Creation
del�ute countries (2001–2010)
- Custom programs
- Major CEE Research and Technical Assistance Projects
- UT McCombs/CEE ExxonMobil Upstream Comm. Overview 1 Program

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Deep Shelf Gas Play
Gulf of Mexico

**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) targets beneath the Gulf of Mexico (GOM) shelf and coastal zone. The study also adds valuable up-dip regional knowledge for companies focused on down-dip 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 deep shelf gas 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 two-year 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.

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**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.

**Challenge**

It is essential to develop compelling case histories that document the value of multicomponent seismic data over conventional P-wave data, and EGL is concentrating on this case-history challenge. The full-elastic seismic wavefield (P-P, SH-SH, SV-SV, P-SV, SV-P) can be constructed only with 9-C data, which can be acquired only onshore and at a cost about twice that of P-wave data acquisition. Only P-P and P-SV modes can be created using marine 4-C data. For cost reasons, onshore operators often defer to 3-C data rather than 9-C data, thus limiting themselves to P-P and P-SV modes, as in the marine environment. EGL works with all of these data types to document advantages, as well as limitations, of multicomponent seismic data.
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.

Seismic estimation of fracture orientation: target depth = 2000 m

(a) Vertical slice from fast-S volume. (b) Equivalent vertical slice from companion slow-S volume. A and B are reflections from targeted fracture-carbonate reservoirs. Horizons aa through ff are used to measure fast-S and slow-S time thicknesses and amplitude attributes across intervals A and B. SR1 and SR2 define image coordinates where slow-S reflectivity diminishes but fast-S reflectivity does not. T1 and T2 define locations where a fractured interval shows an increase in time thickness in slow-S space that is not observed in fast-S space.
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.

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.

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. This project 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
- 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).

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Mission
UT GeoFluids studies the state and evolution of pressure, stress, deformation, and fluid migration through experiments, theoretical analysis, and field studies. This industry-funded consortium is dedicated to producing innovative concepts that couple geology and fluid flow. The results are used to predict pressure, stress, trap integrity, and borehole stability. Our team combines geoscientists at The University of Texas with geotechnical engineers at MIT. Concepts developed in the GeoFluids Consortium have been extended to study marine slope stability and the processes of hydrate formation and disassociation. We have also developed tools to measure pressure in mudrocks.

Impact
Concepts and terminology developed by the GeoFluids Consortium over the last 10 years are now routinely applied in exploration and production. We communicate these results through on-line software, annual meetings, publications, and individual visits.

Major Concepts Developed and Refined
- Protected traps and critical column heights
- Flow focusing
- Nonlinear compaction for pressure prediction
- Salinity-controlled gas hydrate formation
- Direct pore-pressure measurement
- Processes driving submarine landslides
- Pore-pressure prediction in thrust belts
Challenges

- Predict pore pressure and stress in complex tectonic environments (thrust belts and subsalt)
- Assess impact of mineralogy, grain size, and effective stress on mudrock compaction, permeability, velocity, and resistivity
- Develop petrophysical model of the development of anisotropy in mudrocks (resistivity, velocity, permeability)
- Develop coupled models to explore the evolution of pressure, stress, and strain in salt systems
- Train the next generation of basin modelers, basin analysts, and petrophysicists

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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.

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 CO₂. The GCCC has led five major field research projects to develop effective technologies to monitor retention of CO₂ 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 CO₂ sequestration in the deep subsurface, both onshore and offshore
- Measuring and monitoring the retention of CO₂ 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 CO₂ sequestration
- Collaborating with leading regional, U.S., and international researchers
- Enabling the private sector to develop an economically viable CO₂ sequestration industry

Geographic Area

Sources. Refineries and chemical plants along the Texas, Mississippi, and Louisiana Gulf Coast produce CO₂ streams that are being tapped to start the sequestration process through enhanced oil recovery (EOR). These large sources of CO₂ 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 CO₂ storage, which are now underway. New energy resources in residual oil zones require CO₂ 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.

- **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\textsubscript{2} sources.

  **SECARB Stacked Storage.** Monitoring of 5 million metric tons of CO\textsubscript{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\textsubscript{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\textsubscript{2}.

  **West Texas Study.** Long-term injection at SACROC field, Curry County, showed no impacts from CO\textsubscript{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\textsubscript{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.

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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 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 and 3D geophysical data

Research Methods and Tools

- Nanopore analysis: field-emission SEM microscopy, Ar-ion milling, and atomic force microscopy
- 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 and X-ray CT
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
- Smithwick
- Spraberry/Dean
- Wolfcamp
- “WolfBerry”
- Woodford
- Zechstein Permian

Mesozoic
- Eagle Ford
- Haynesville
- Pearsall
- Tuscaloosa

Cenozoic/Recent
- Frio
- Wilcox
- Nankai accretionary prism

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**Mission**

The mission of clastic systems research at the Bureau is to provide our industry members a source for rigorously collected, carefully analyzed, and systematically organized data on clastic reservoir architecture and depositional system morphology, as well as for regional context studies, modeling methodologies, and data-collection techniques and tools so members can assess their own data.

**Goals**

- To populate and maintain the Sedimentary Analogs Database - Morphometrics Module (SAND-M), which assists members in searching and selecting the range of reservoir elements, and their dimensions and properties, for constructing accurate geologic models, calculating accurate volumetrics, and assessing flow behavior in clastic reservoir systems.

- To develop predictive models of clastic systems architecture, development, and response to change.

- To educate students and advance scientific understanding of the evolutionary process of continental margins around the world.

**Approach**

The project team utilizes both small (hundreds of sq km) and large (thousands of sq km) 3D seismic data sets to allow harvesting of clastic architectural data on various elements of the depositional systems. Seismic architecture is investigated using techniques that employ conventional seismic sequence framework development, quantitative seismic geomorphologic analysis, various attribute extractions, export and harvesting of morphologic information in ArcGIS and ErMapper, and import of these data into various programs for statistical analyses of temporal and spatial distribution and relationships.

The team also works with a significant legacy archive of outcrop data provided from decades of clastic systems research at the Bureau, as well as with data from current outcrop studies. These outcrop results consist of thousands of detailed facies, lithology, and shale architecture measurements, integrated with over 100 kilometers of detailed architectural drawings from photopanoramic images. Datasets include significant subsurface logs integrated with outcrop data, as well as porosity, permeability, and velocity measurements. These data are being harvested for the morphologic information that they document. Both the seismic-derived and outcrop-derived data form the basis for probabilistic models of reservoir occurrence, character, and evolution. Results are conveyed to members as statistical data sets, and as modeling studies using both Schlumberger’s Petrel and Landmark’s DecisionSpace softwares, and are combined with results from published works and previous studies to form a larger searchable Sedimentary Analogs Database (SAND).
Sedimentary Analogs Database - Morphometrics Module (SAND-M)

The SAND-M module is a boolean searchable analog database that contains thousands of dimensional and properties measurements of clastic reservoir and seal elements from modern and ancient systems studies. These data are tied to key characteristics such as structural setting, depositional setting, dominant grain size, and seismic or log character, which all enable member users to narrow their search for quantitative architectural morphometrics and properties that best represent their own systems. SAND-M is an organic database that is continually added to and improved.

SAND-M is supported by a much larger database of material that includes published papers, theses and dissertations, presentations, posters, and white papers on past and present Quantitative Clastics Laboratory study areas. Access to SAND is limited to active members.

Terms

- The research calendar each year begins January 1 and runs through December 31.
- Multiple meetings, core workshops, and/or field trips are held annually.
- Each year there is a two-day visit to member offices to work with geoscientists and teach.
- SAND access is limited to active members; however, annual meeting presentation material remains available to inactive individual members through website portals.

Contact

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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

♦ Seismic imaging and inversion of carbonate facies and pore systems

♦ Mapping, characterizing, and modeling of non-matrix 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.
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 2010–2012 biennium, the STARR project added ~$153 million to the Permanent School and General funds from royalties and severance taxes from increased production.

Impact

Texas leads the United States in oil production, accounting for more than 2.4 million barrels per day as of April 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.
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.
TCCS is a collaboration between the Bureau of Economic Geology and the Center for Numerical Analysis at ICES (Institute for Computational Engineering and Sciences).

Mission

- To address the most fundamental and challenging problems in the energy industry that can be solved by employing multidisciplinary research with focus on computational geophysics
- 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 software code required for reproducing and verifying the experiment.
Examples of Focused Research Projects

- Seismic Wave Focusing for Subsurface Imaging and Enhanced Oil Recovery
- 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

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