2023

Research Consortia

Bureau of Economic Geology

Scott W. Tinker, Director

Research Consortia

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Research Partnerships with the Bureau of Economic Geology

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

Collectively, these consortia enjoy the support of global partners, with some companies and organizations participating in multiple separate programs. Each research consortium was designed to complement industry efforts to explain a key exploration, production, environmental, or economic problem. Participation is on a subscription basis. Member benefits vary but generally include first look privileges at 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 organizations.

Each Bureau research consortium has a dedicated team of full-time researchers, including postdocs. Many of them host talented graduate students, creating combined teams of seasoned experts and 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 research consortia, or about the breadth of your organization's engagement with the Bureau, please contact us at mark.blount@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 research unit at The University of Texas. The Bureau is 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. Our mission is to serve society by conducting objective, impactful, and integrated geoscience research on relevant earth resources, energy, environmental, and economic issues. Our vision is to be a trusted scientific voice to academia, industry, government, and the public, all of whom we serve. 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, machine learning, 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
- Geothermal energy
- Hydrogen storage and technology
- Earthquakes and geologic hazards

Talented people are key to the Bureau's success. The research staff includes more than 200 scientists, engineers, economists, graduate students, and postdocs, representing 27 countries, working in integrated, multidisciplinary research teams.

UT Bureau of Economic Geology

Partnerships

Partnerships drive strategy, innovation, and investigation, and the Bureau engages partners, both new and old, on many levels. Investments in Bureau research provide significant returns. Corporate partners participate in and gain vital new insights from the Bureau's many productive 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 solutions. Such facilities and equipment include

- More than 19 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 that collectively house 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

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

- Over 150 peer-reviewed articles, books, and maps published annually
- Hundreds of abstracts and articles published each year in *Conference Proceedings* volumes
- More than 50 keynote addresses made annually
- Bureau researchers frequently serve as presidents of international professional societies and editors of major professional journals
- Bureau researchers are continually recognized by their peers with top medals in their fields

Advanced Energy Consortium

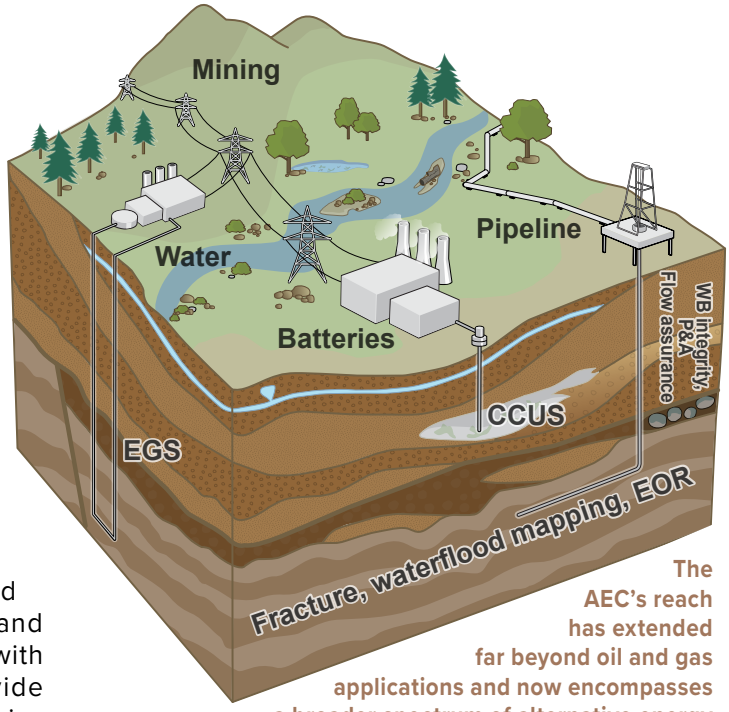
Mission

The mission of the Advanced Energy Consortium (AEC) is to develop disruptive nanotechnology to enable transformational improvements in subsurface sensing, energy recovery, and environmental protection.

Research Challenges

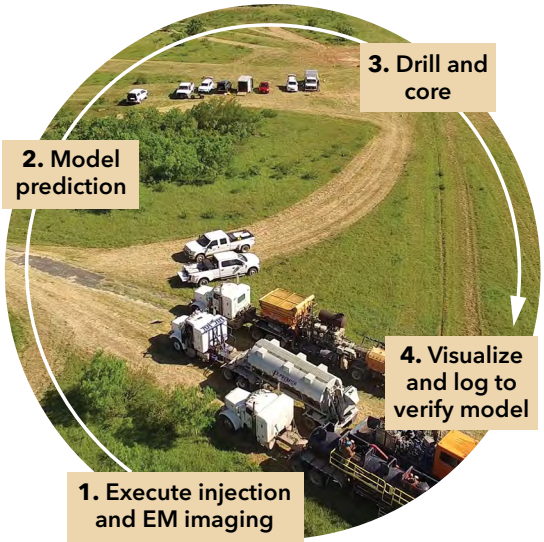
Over the last 12 years, the AEC has been a pioneer in developing micro and nanoscale sensors and smart materials to help illuminate the subsurface. Our research now enables the remote monitoring of subsurface processes for environmental health, safety, energy, security, and structural integrity. It will also prove to be a game changer in the quest for breakthrough alternative energy solutions.

The AEC's technology reach is extending beyond the original mission, which was focused on oil and gas exploration. We are now targeting CO_2 sequestration and utilization, pipeline surveillance, environmental monitoring, cement integrity, geothermal systems, H_2 storage, rechargeable high-temperature batteries, and more. The development of distributed, real-time, and miniaturized subsurface sensors and materials, with the associated data analytics, promises to provide revolutionary monitoring tools to our member companies to address the emission transition in a more economical and environmentally safe manner.



The AEC's reach has extended far beyond oil and gas applications and now encompasses a broader spectrum of alternative energy and environmental applications.

Proof-of-concept demonstration and validation workflow



Research Thrusts

Contrast Agents for Mapping Hydraulic-Fracture Networks

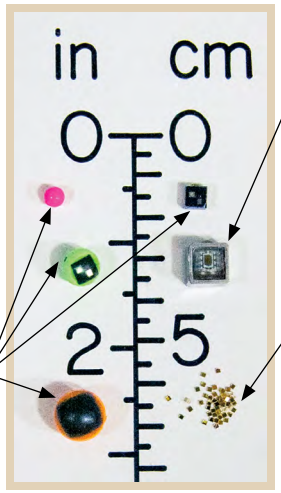
The Use Case 1 (UC1) team is focused on remote characterization of hydraulic-fracture geometries and network permeability using electromagnetic (EM) contrast-agent proppants. Current fracture-imaging technology employs microseismic monitoring, which provides general information about rock mechanics but fails to accurately resolve the extent of connected-fracture geometry and fluid permeability within the fractured network. Accurate mapping of hydraulic fractures is instrumental in enhancing completion strategies and mitigating excessive resource usage.

Advanced Energy Consortium

Research Thrusts *(continued)*

Microelectronic Sensor Systems

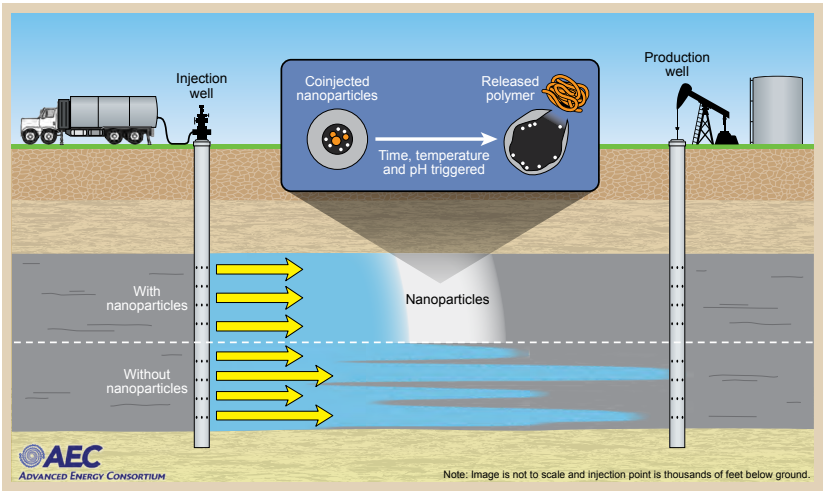
The Use Case 2 (UC2) team designs and fabricates microelectronic sensors capable of acquiring multiple time-stamped measurements in harsh subsurface environments. The AEC has tested three Smart Subsurface Autonomous Nanosensor Device (Smart-SAND) prototype platforms and has continued to develop new sensor, power, microcontroller, and communications components. The three platforms ranged in size from 1 to 12 mm and were hermetically sealed, wirelessly charged and programmed, and suitable for characterization of any combination of temperature, pressure, resistivity, or pH (up to 10 kpsi and 125°C).



Stacked chip system (5–12 mm)
Temp., pressure, and time combo. Polymer packaging. Battery lifetime of 10–40 hr.

System on a board (8 mm)
Temp., pressure, and time combo. Steel packaging. Battery lifetime of 10–16 hr.

System on a chip (1 mm)
Discrete temp., press., resistivity, and pH. Thin film packaging. Radio frequency powered (batteryless) with a 30-year lifetime.



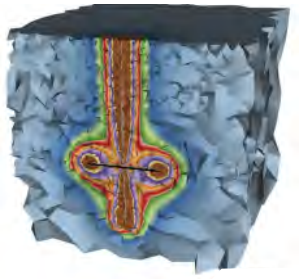
Payload Delivery Systems

The Use Case 4 (UC4) team continues to progress in the development of micro and nanoscale payload-delivery systems. Timed payload delivery allows for optimal placement of the cargo in the wellbore or reservoir. Two payload-delivery system mechanisms have been developed: (1) burst release with an inside out, triggered degradation mechanism and (2) core–shell delivery, in which the payload dissolves at desired temperatures and times.

Membership

Now is truly an excellent time to be a part of the AEC family. AEC research revenues are increasing as we attract new members. We have also successfully obtained grants from Sandia National Laboratories and the U.S. Department of Energy that promise to offer members more than a 15 times increase on their research budget investment over the next two years. Our level of innovation remains unsurpassed, and we are a recognized leader in nanotechnology research, as demonstrated by our numerous filed patents and papers and our team's prestigious 2019 Best Paper Award from the Journal of Environmental & Engineering Geophysics.

We invite companies who are ready to transform the future of the energy industry to talk with us about empowering people and protecting the environment using advanced technology.



Simulations indicate that a combination of steel wellbore casing and EM additives could supply continuous electrical power to embedded nanosensors.

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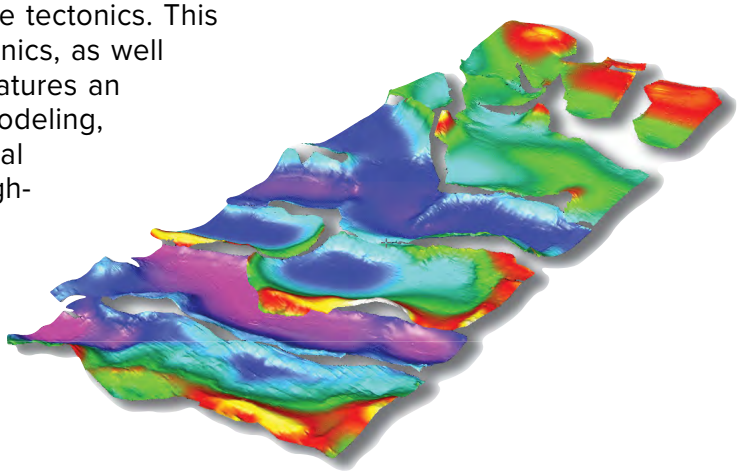
Applied Geodynamics Laboratory
Salt Tectonics

Mission

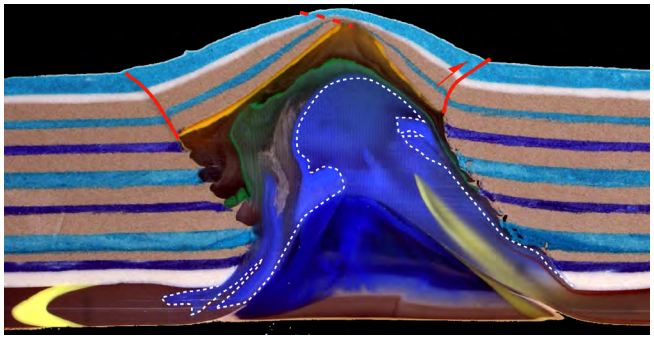
At the heart of this research is the Applied Geodynamics Laboratory (AGL), an industry-funded consortium dedicated to producing innovative concepts in salt tectonics. Research comprises a mix of physical and mathematical modeling, seismic- and field-based mapping, and structural stratigraphic analysis 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.

In 2017, AGL added a new research effort in shale tectonics. This work builds on our existing expertise in salt tectonics, as well as our experience in soil mechanics. Research features an integration between seismic interpretation and modeling, finite-element modeling, and subaqueous physical modeling. We are initiating case studies using high-quality 3D seismic data in the Gulf of Mexico and eastern Mediterranean to learn more about the geometry and evolution of shale structures.



Research Thrusts

Concepts and terminology pioneered by the AGL over the past quarter century have profoundly influenced salt tectonics and are now widely disseminated throughout the oil industry. The AGL strives to effectively communicate these results via a variety of media, including *Salt Tectonics: Principles and Practice*, the leading textbook on the subject in the world.



Research Challenges

The primary goals of the AGL are to develop a conceptual framework for the full range of salt tectonics and shale tectonics; to analyze connections among physical models, mathematical models, seismic data sets, and field examples from all over the world; and to disseminate complex technical information to a constantly shifting spectrum of industrial and academic supporters.

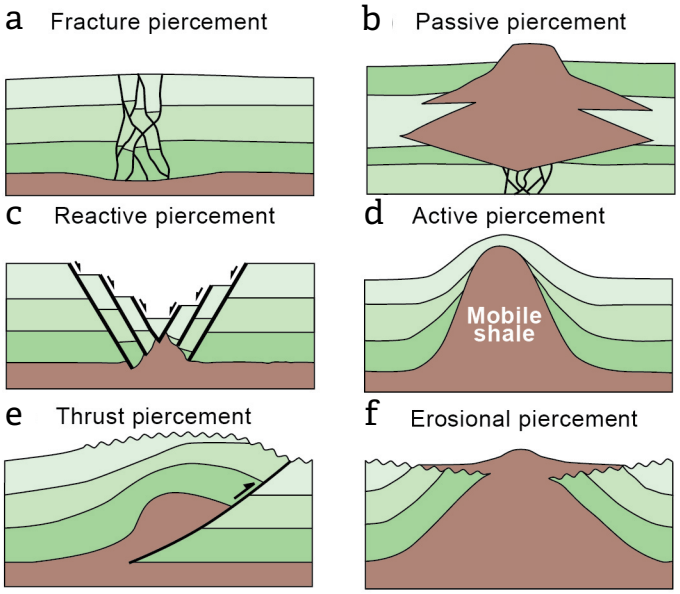
Areas of focus for salt tectonics include salt welds; salt canopies; reactive, falling, and squeezed diapirs; mechanics of salt-sheet advance; the origins and evolution of minibasins; internal salt structures; and salt sutures.

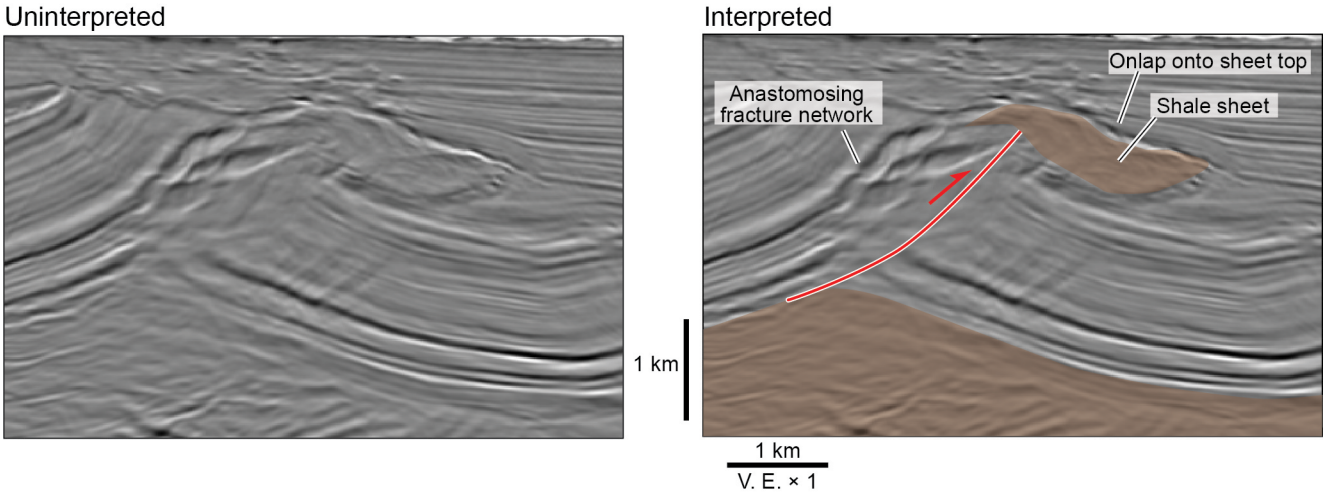
Areas of focus for shale tectonics include mechanical models for mobile shales, mobile-shale piercement mechanisms, and variables affecting the seismic expression of shale diapirs.

Applied Geodynamics Laboratory
Salt Tectonics

Membership

The 29 supporting companies of the AGL include a wide range of industry partners from around the world.





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Center for Injection and Seismicity Research

Mission

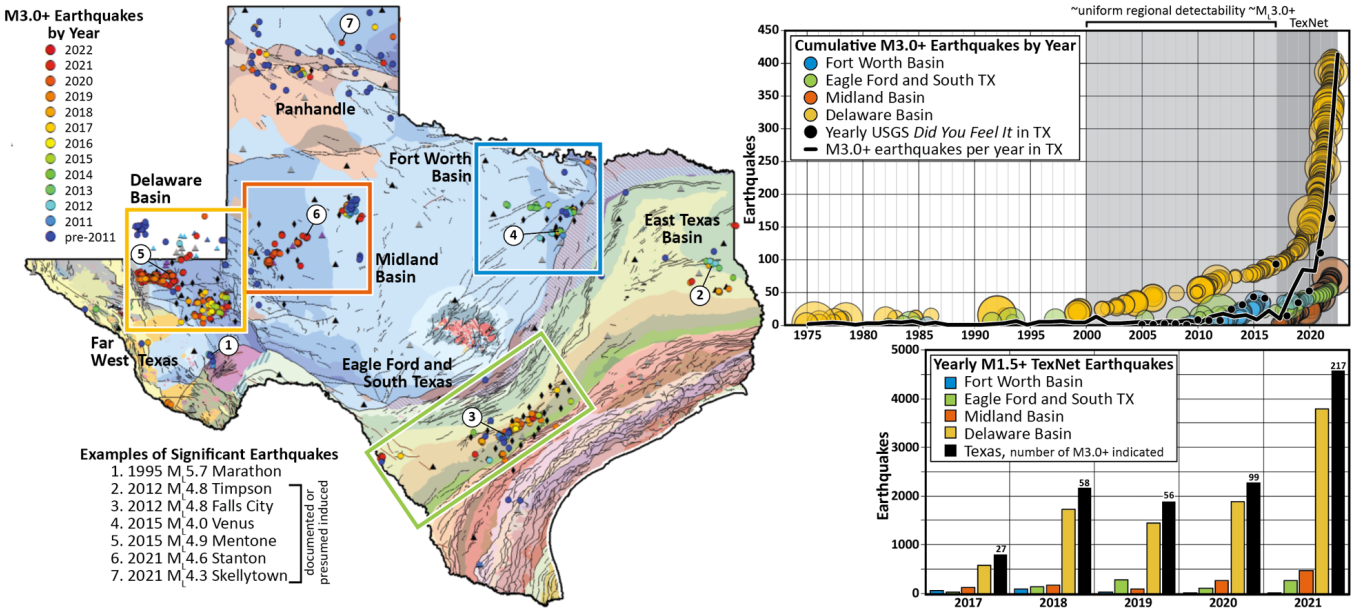
The Center for Injection and Seismicity Research (CISR) is a multidisciplinary, intercollegiate research consortium managed by the Bureau. TexNet and CISR are two parts of a whole; the former is the State-funded network of seismometers across Texas that monitors and catalogs earthquakes and conducts research into monitoring and aspects of causation. With its upstream and midstream partners, CISR significantly extends and deepens the scope of research into induced seismicity in Texas, New Mexico, and globally. Goals include developing an understanding of the processes that influence seismicity, quantifying the evolving hazard, and improving standards of practice for mitigation.

Research Thrusts

CISR conducts fundamental and applied research to better explain seismicity of all causes and its associated hazards. Thorough geologic, geophysical, and reservoir engineering integration underpin all CISR programs. CISR relies on research specialists from the Bureau, the Department of Geologic Sciences, the UT Institute for Geophysics, and the Hildebrand Department of Petroleum and Geosystems Engineering. We also partner with many research institutions in Texas and internationally.

Research Challenges

The rate of seismicity in the south-central United States has increased markedly over the past decade, especially in unconventional play areas where water management and sustainable development are increasingly important challenges. In Texas, the impacted areas have evolved rapidly and complexly from quiescence to high earthquake activity. Understanding the interplay between complex operational drivers and interdependent subsurface physical processes is a daunting challenge that the Bureau is pursuing head-on.

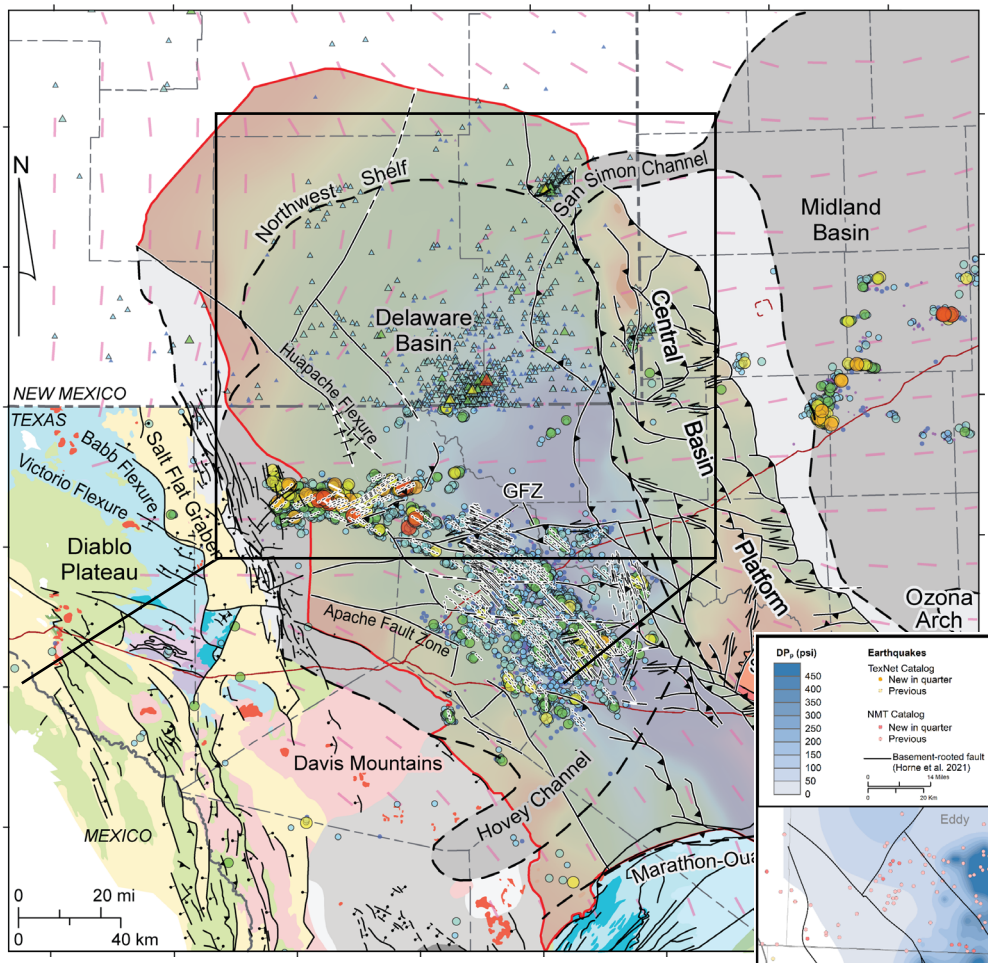


Areas of study by the TexNet-CISR collaborative and history of earthquakes of M3.0+ (left). Cumulative history of M3.0+ earthquakes in (upper right) in the four regions as indicated on the map (left). The yearly total of M3.0+ earthquakes is shown in the lower right.

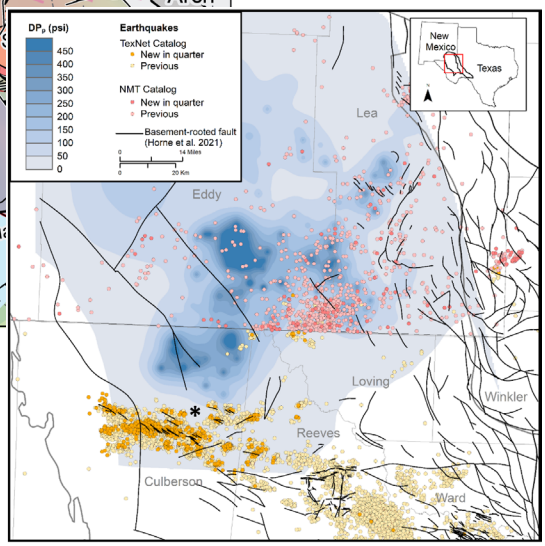
Center for Injection and Seismicity Research

Membership

Most of the major energy companies that operate in Texas' unconventional plays are CISR members, as are key midstream operators. Key international operators are also members. Each company has one member who serves on the CISR Advisory Committee, which meets quarterly to discuss the design and application of CISR-TexNet research and monitoring projects. Member companies are encouraged to assist with the identification of land parcels that can be used for seismic monitoring and to contribute proprietary data and information that can guide and advance CISR research. Proprietary data is protected by The University of Texas at Austin's strong intellectual property controls.



Map showing the distribution of earthquakes monitored by TexNet and its partner's seismic networks in the Delaware Basin of West Texas and southeast New Mexico (left). Faults that have the potential to become seismogenic are shown as studied by the TexNet-CISR collaboration.



Map showing pore pressure change from injection into strata above seismogenic basement (right). CISR is studying the relationship between the rate of stress change from injection and the distribution and nature of the related induced earthquakes.

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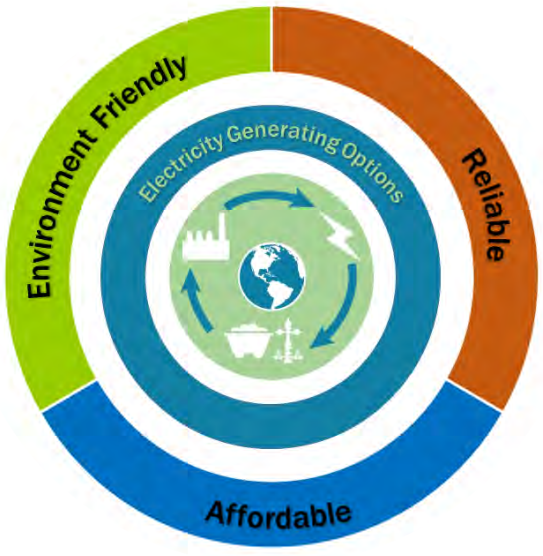
Comparing Electricity Options

Mission

The mission for the Comparing Electricity Options (CEO) research program is to understand local and global environmental impacts associated with different electricity generation technologies. This is done using data-driven life cycle analyses (LCA) of the global supply chain of electricity generation options and highlighting the trade-offs between society's goals of mitigating climate change, improving local environments, and providing reliable and affordable electricity at both system and end user levels. CEO focuses on communicating understandable and decision-relevant results to a wide array of stakeholders, from energy and related industries to policy makers to the public.

Research Thrusts

A comprehensive life cycle analysis of different electricity generating options, based on internationally recognized standards (ISO 14040 and 14044), can provide a side-by-side comparison of environmental impacts across the global supply chain needed to build these systems. CEO conducts these studies using a broadly defined boundary from where critical materials are sourced to where electricity generation equipment is disposed at facility end of life (known as cradle to grave). We include a broad array of environmental impacts: greenhouse gas and local emissions, land- and water-use and pollution, biodiversity and ecosystem services, and the impacts from front-end loading under various transition scenarios.



Conceptual image showing how CEO is balancing factors.

We are currently comparing combined cycle gas turbines (CCGT) and utility-scale wind and solar, with and without batteries, using equivalent annual generation rather than capacity. We investigate natural gas production and delivery to the CCGT plant, as well as several materials that are necessary for manufacturing wind, solar, and battery equipment. Necessary materials include lithium, cobalt, nickel, copper, and rare earths. The generation technologies will be combined into a reliable grid mix with minimum environmental impacts. We will then aggregate power system and environmental externality costs to estimate the total social cost of electricity for end users. Other electricity technologies will be included later in the project.

We envision CEO results to inform the environmental, social, and governance (ESG) standards that are currently under development. We will develop flexible models and tools that support decision and policy makers with their overall economic and environmental assessment to manage supply chain and ESG risks, based on current and projected commodity demands.

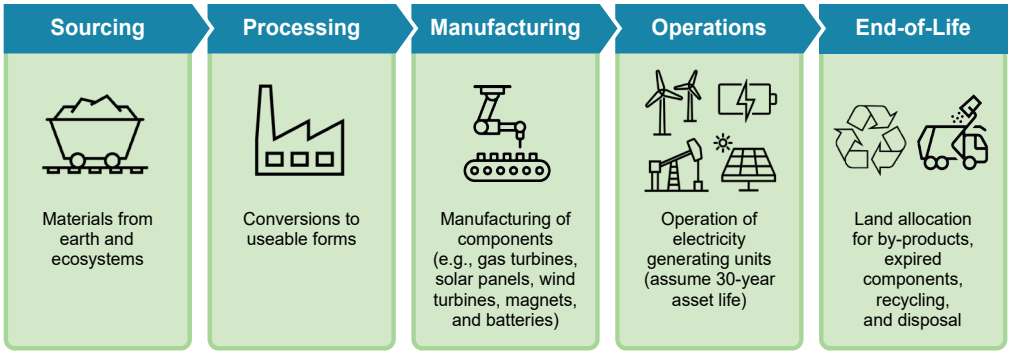
Research Challenges

Globally, the energy transition away from greenhouse gas (GHG)-intense, carbon-based fuels and toward more sustainable and renewable energy is widely accepted as a means to mitigate the impact of climate change. However, a societal shift in electricity generating technologies is extremely complex at national and global scales. There are numerous uncertainties across policy, regulatory, and technology dimensions that need to be addressed to avoid negative unintended consequences.

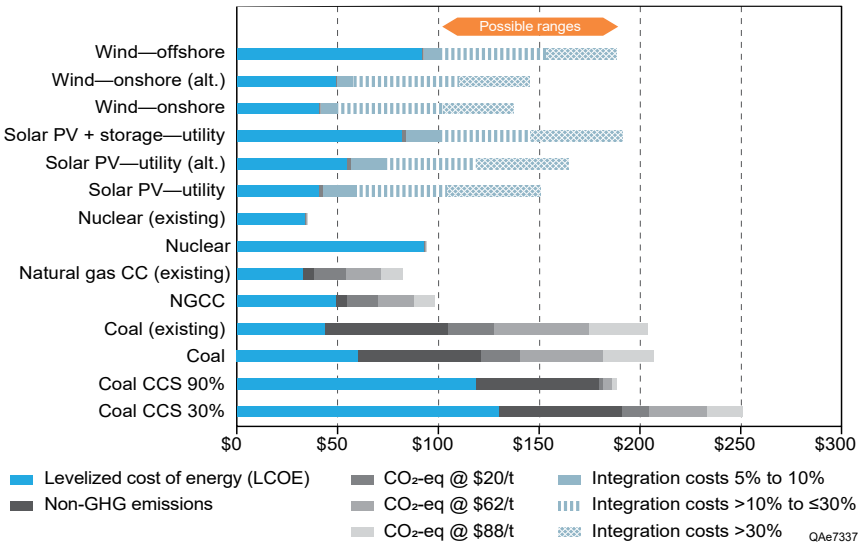
Comparing Electricity Options

Research Challenges *(continued)*

CEO is intended to contribute to better visualization and communication of this puzzle by focusing on LCAs across supply chains of several key generation technologies, using publicly available software platforms and data sets built from data providers and meta-analyses. Data availability and data quality for mining, manufacturing, and energy operations around the world have been recognized in the literature as a significant challenge. In some cases, we estimate original impact factors based on bottom-up engineering analysis and industry communication.



Boundaries and processes included in the LCA analyses.



Economic and social cost of delivered electricity in a generic U.S. location (Gülen, 2019).

In addition, CEO's goals are to (1) provide the public, businesses, and policymakers with quantifiable information on potential impacts; (2) support analyses that determine the most affordable and environmentally optimal power generation mix for specific locations; and (3) identify where innovation, efficiency, and technology can lead to a better balance of consistent availability of electricity and sustainable environmental resources.

Membership

Members help develop multiyear research plans and goals, provide feedback on research approaches and communication strategies, and meet with CEO researchers and students through on-site or virtual meetings.

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Fracture Research and Application Consortium

Mission

Fracture research at The University of Texas at Austin seeks a fundamental understanding of 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 research is both fundamental and practical, aiming at improving prediction and diagnosis of fracture attributes in hydrocarbon and geothermal reservoirs and accurately simulating their influence on production. Research is organized around the Fracture Research and Application Consortium (FRAC), conducted together with scientists from member companies. Students are an important part of our program.

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

Research Thrusts

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 produce data that can enhance well test and seismic interpretations and can be used in reservoir simulators. We are developing new and more reliable methods to predict hydraulic-fracture propagation in naturally fractured and unconventional reservoirs.

Fieldwork with FRAC's drone and new trace map methods reveal patterns essential to fluid-flow modeling. Example: outcrop analog of geothermal target.

Research Challenges

Faults and fractures are difficult or impossible to characterize adequately using currently available technology. Fractures have been challenging to sample and model, posing serious challenges to exploration and development. Our approach is helping to overcome the limitations of current methods.

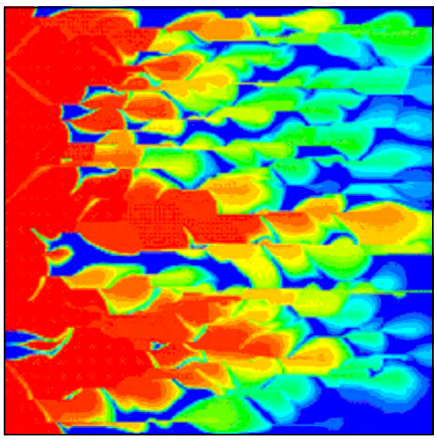
FRAC members get hands on training in fracture analysis on annual field trips.

Fracture Research and Application Consortium

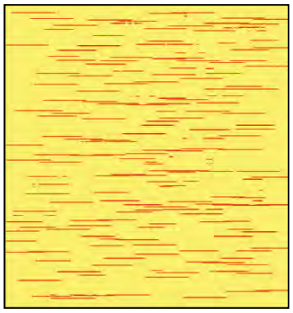
Membership

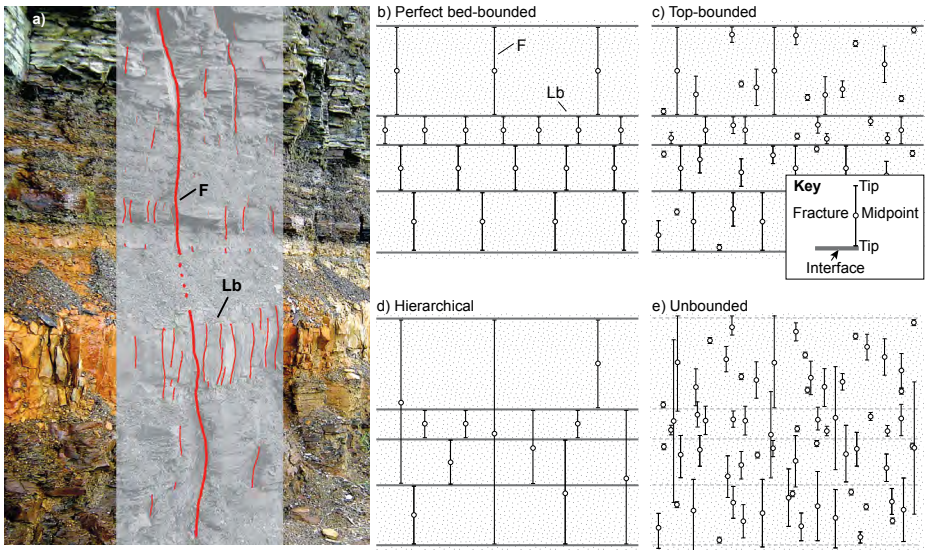
Training in techniques, software, and our workflow is a benefit of membership. Annual meetings cover measurement, interpretation, prediction, and simulation of fractures and mechanical properties in carbonate rocks, mudstones, and sandstones.

Flow simulation

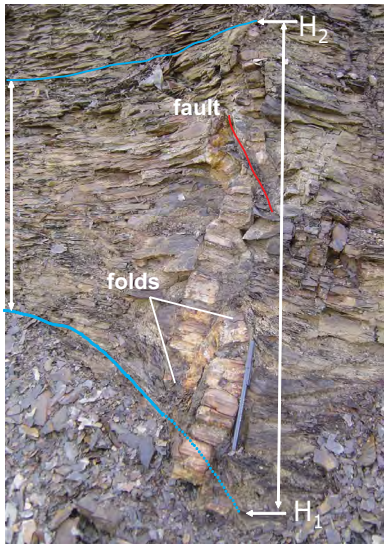


Fully 3D "Joints" software for fracture modeling and permeability estimation





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



Quartz, dolomite, and bitumen-filled fracture compacted by folding and faulting. The H_1-H_2 compacted fracture height is 70 cm, from the Blocher Member, New Albany Shale, Kentucky.

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GeoH$_2$

Mission

GeoH$_2$, a new industrial affiliates program, conducts geoscience and economic research to facilitate and advance the development of a hydrogen economy at scale. GeoH$_2$ connects industry professionals in the energy and power sector with researchers in energy geoscience, subsurface engineering, and energy economics to conduct subsurface hydrogen storage research and technology development, perform market feasibility analyses, and explore novel subsurface concepts related to hydrogen.

Research Challenges

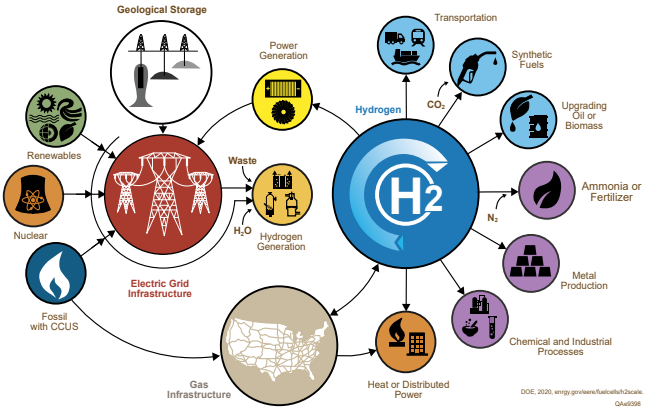
Hydrogen (H_2) offers the potential for a transportable, storable fuel for a low-carbon economy. Hydrogen can be generated renewably using electrolysis and from natural gas, which when combined with carbon capture and storage can reduce greenhouse gas emissions. However, storage capacity for hydrogen is inadequate to allow for supply beyond current industrial usage.

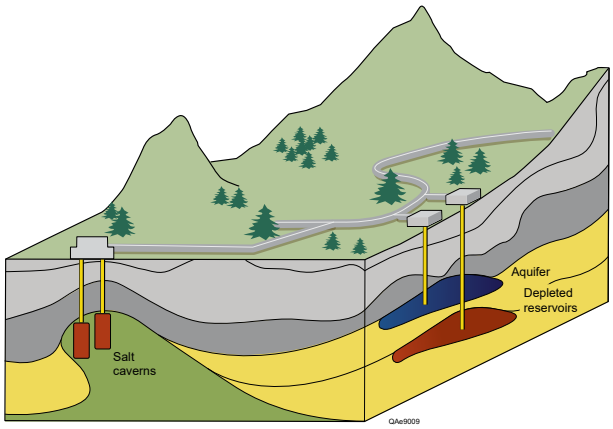
Importance of Geological Storage

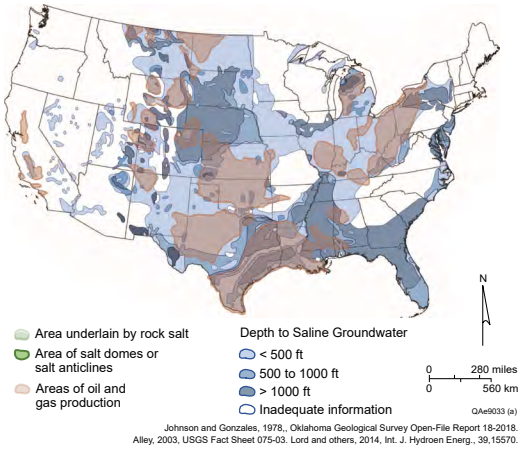
Geological storage combined with surface storage, hydrogen pipelines, and transportation infrastructure connecting supply to end users is essential for large-scale hydrogen systems and value chains. At present, hydrogen is stored for industrial usage in salt caverns at three sites in southeastern Texas along the Gulf Coast. Salt caverns present the advantage of allowing fast withdrawal and injection rates but are restricted to areas with salt at the right depth. Porous media (e.g., sandstone) reservoirs offer larger capacity and more widespread and abundant opportunities for storage.

GeoH$_2$ Research and Technology Portfolio

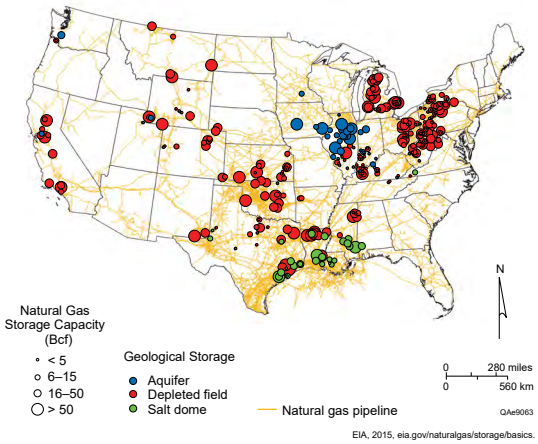
Our research and technology development addresses four aspects of underground hydrogen storage: porous reservoir storage, salt cavern storage, in situ hydrogen generation, and techno-economic and value chain analysis.







Johnson and Gonzales, 1978., Oklahoma Geological Survey Open-File Report 18-2018.
Alley, 2003, USGS Fact Sheet 075-03. Lord and others, 2014, Int. J. Hydroen Energ., 39,15570.



EIA, 2015, eia.gov/naturalgas/storage/basics.

GeoH$_2$

Research Thrusts

Hydrogen Storage in Porous Reservoirs

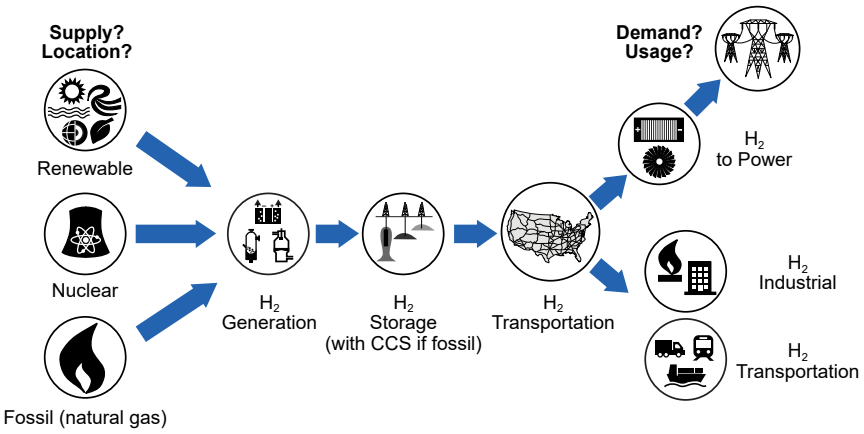
While subsurface hydrogen storage can build on decades of natural gas underground storage, the unique properties of hydrogen require an adaptation of existing storage technology to account for differences in storage capacity, reservoir integrity, and requirements on hydrogen purity. Research activities include reservoir modeling coupled with laboratory experiments to understand the behavior of hydrogen in the reservoirs as well as suitability analyses to identify reservoir types and fields that would be appropriate for designing and conducting pilot tests.

Salt Cavern Storage

Hydrogen storage in salt caverns is a proven technology for industrial applications. However, not all salt bodies are the same and heterogeneities are poorly understood. Our research addresses domal and layered salt bodies.

In Situ Generation of Hydrogen

Hydrogen can be generated from in situ combustion (ISC) of hydrocarbons as well as from underground coal gasification under controlled conditions. We investigate the potential of ISC for the primary purpose of hydrogen generation from hydrocarbons in the subsurface.



- What are the optimum storage and transportation options for various market scenarios?
- Interconnection and trade-offs of the new technologies versus existing options?
- Opportunities for conversion of oil and gas infrastructure to hydrogen?

Many scenarios, many questions.

QAe9136

Techno-Economics and Hydrogen Value Chain Analysis

Scaling up the hydrogen sector requires a dedicated and developed transportation and storage infrastructure system. We evaluate the technology options for hydrogen supply, demand, transportation, and storage to develop a system-level understanding to inform preferred options for the fast emerging value chains.

Membership

Consortium members meet twice a year for research and development reviews and participate in topical workshops. Training and sponsor-company visits can be arranged in person or virtually. Sponsorship is $75,000 per year.

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Gulf Coast Carbon Center

Mission

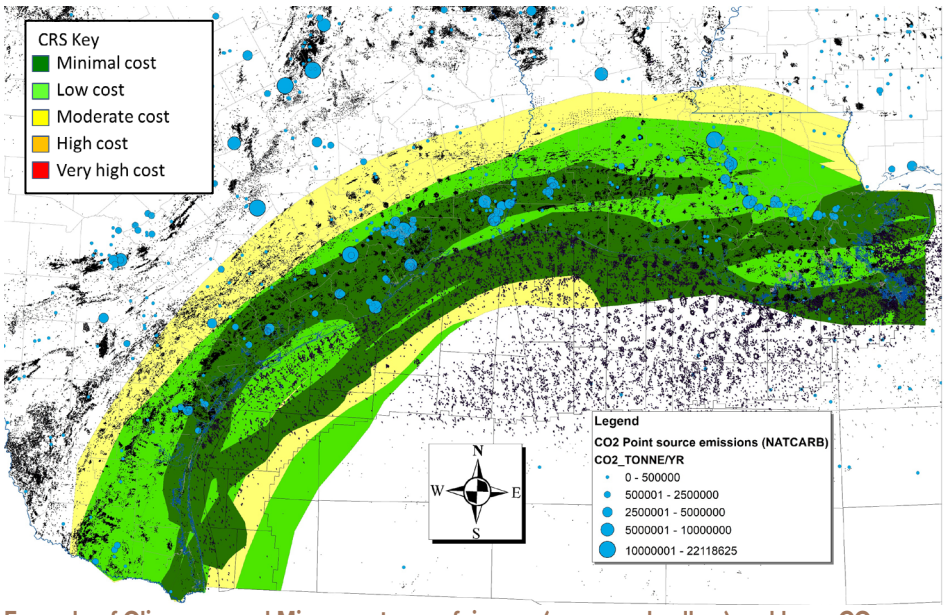
The Gulf Coast Carbon Center (GCCC) works with industry, nongovernmental organizations, and governments to develop and conduct targeted and commercially applicable research to optimize storage of CO_2 in geologic formations in the deep subsurface. The GCCC has a mission with a global reach to provide state-of-the-science information to serve diverse stakeholders, from local residents to international industries. The GCCC also educates the next generation of CO_2 storage geoscientists.

Research Thrusts

GCCC research increases confidence in the large-volume storage resources to support the commercialization of carbon capture and storage (CCS). GCCC collects (1) multiscale laboratory and field-scale fluid-flow data; (2) uses advanced physical and numerical simulation and machine learning techniques to upscale and optimize storage; (3) creates workflows at basin scale that prepare multiple sites to be operated at maximum injection rates over prolonged time periods; (4) improves structural and stratigraphic characterization methods and simulation approaches to identify and permit sites; and (5) develops and assesses methods for monitoring in reservoir, overburden, groundwater, marine and land surface to provide assurance that storage is effective.

GCCC students Shadya Taleb and Richard Larson are expanding GCCC capabilities to assess CO_2 migration and stabilization by developing micromodel flow through imaging capabilities.

Development of large-volume storage is needed in the very near future to accept CO_2 captured from current point sources. This includes hard to abate sources such as refining, chemicals, cement, and steel manufacturing and CO_2 produced as part of blue hydrogen, bio-energy for carbon abatements, and Direct Air Capture. Information on the value and impacts of future development is needed to support community decision-making.



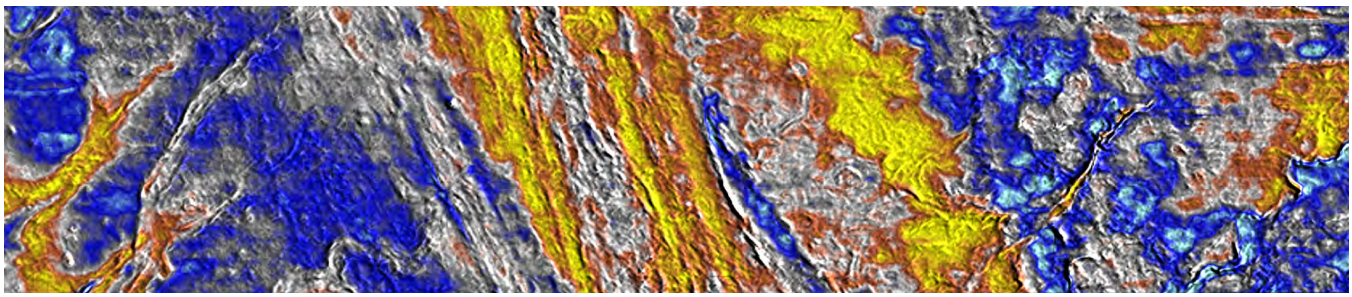
Example of Oligocene and Miocene storage fairways (green and yellow) and large CO_2 emission sources (blue dots). Black dots indicate well density. Additional fairways are under assessment.

Gulf Coast Carbon Center

Research Challenges

Industry and government interest in the reduction of carbon emissions is on a rapid upswing. However, many stakeholders, from industrial investors to policymakers to journalists, do not have the information needed to evaluate the risks, benefits, and the critical role of CCS in comparison to other mechanisms for attaining climate goals. GCCC addresses information gaps via: (1) providing substantive technical information; (2) translating technical information so that it is accessible to users; and (3) targeting research to reduce uncertainties.

GCCC staff experience leads to a trained CCS workforce.



High-resolution seismic slice collected in shallow water allows improved above-zone monitoring design.

Membership

Members develop aspirational multiyear goals, oversee the incubation of new research thrusts, seek augmentation via increased investment, receive a quarterly newsletter, and meet twice per year for research review.

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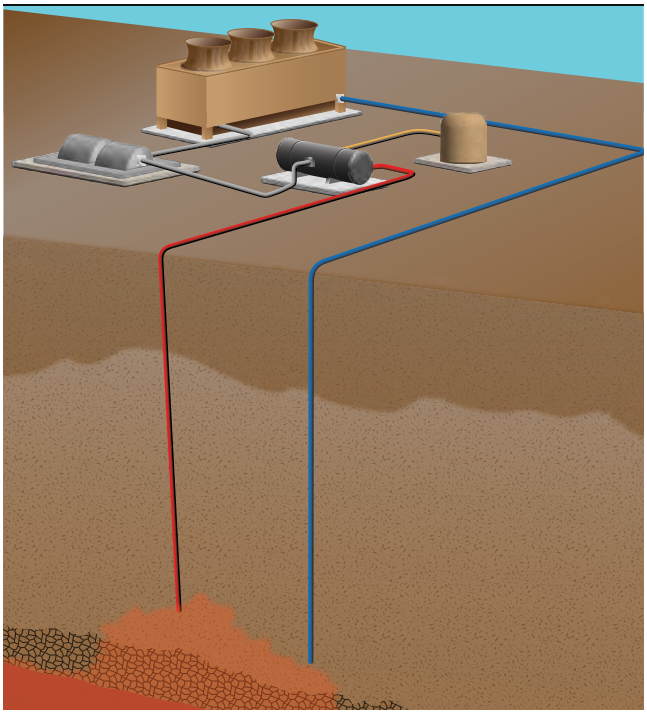
HotRock
Geothermal Research Consortium

Mission

The HotRock Geothermal Research Consortium will integrate the isolated bodies of science and engineering knowledge to broaden and accelerate the scale-up of geothermal power anywhere.

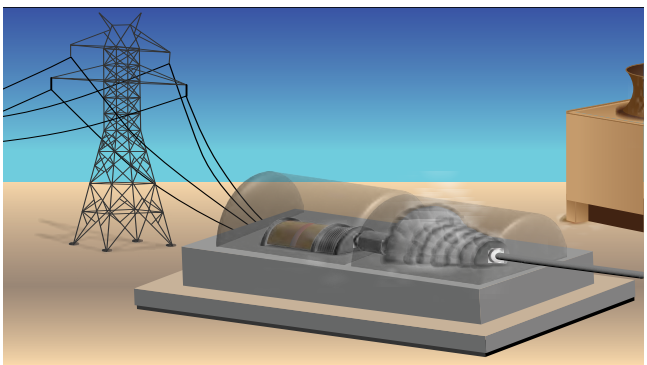
HotRock is an industry-funded research consortium to find and fill the science and technology gaps needed to further develop the geothermal anywhere ecosystem. This will incorporate science, engineering, economics, policy, and entrepreneurship efforts and will be led by the Bureau, an organization with the skills and proven track record to lead a major enterprise such as this.



Research Challenges

The HotRock research consortium will address the broadest range of research and engineering topics, from deep within the subsurface to the consumer:

- Subsurface geology and engineering
- Surface power generation, grids, economics, and policy
- Direct heat applications for heating and cooling, agriculture, etc.



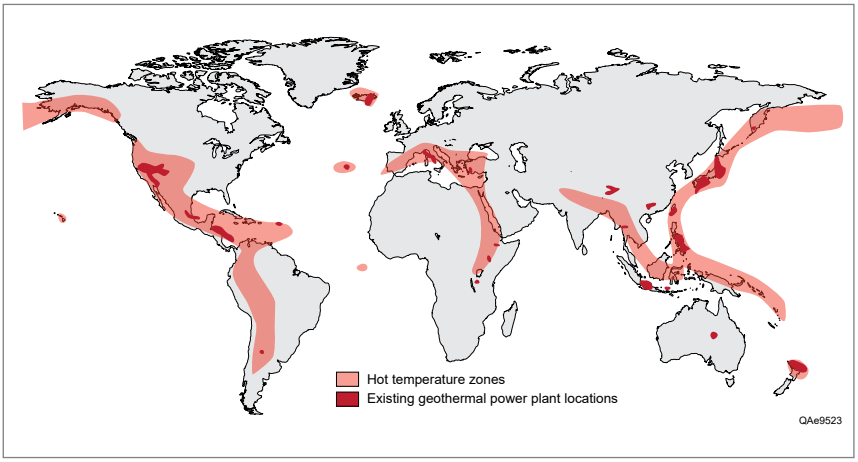
HotRock Geothermal Research Consortium

Research Thrusts

As these applications have disruptive impact in the race to lower carbon emissions, the scope will be international, exploring how resources and certain technologies that are successful in one region could be scaled up in others.

Evident issues that need work include but are not limited to the following:

- Fit-for-purpose geothermal reservoir characterization: best indicators of suitable heat reservoirs—transfer of oil and gas methodology into geothermal
- Downhole tools and methods for well construction, well monitoring, and production enhancement
- Modeling heat transfer in fractures and into wellbores
- Supercritical CO_2–rock interactions
- Induced seismicity monitoring and mitigation
- Higher-temperature materials, sensors, cements, etc.



Current geothermal development is limited to specific geographic areas, leaving most of the Earth out of the geothermal power picture. However, advances in technology (the new paradigm) are opening up much more of the Earth's surface to geothermal development.

- Comparing designs and economics of diverse methods for harvesting heat
- Techno-economics of converting heat to electricity
- Low-temperature heating and cooling uses—a more efficient use of heat than generating electricity and a potentially larger profitable market

Membership

Consortium membership costs $75,000 per year. Companies will be able to collaborate with the principal investigators and researchers, obtain all the research results, and influence the areas of research. Each member company will appoint a representative to the advisory board to help make strategic decisions on spending and research.

HotRock will organize annual meetings attended by the sponsors and other invited guests as appropriate. The primary goals of the meetings will be to showcase the research performed by this consortium, as well as by certain collaborators and partners, and to discuss the research strategy going forward.

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www.beg.utexas.edu/hotrock

Mudrock Systems Research Laboratory

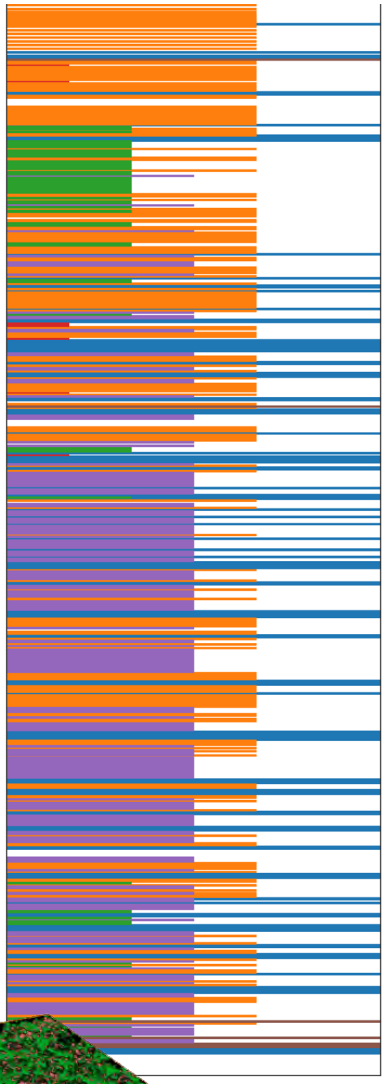
Mission

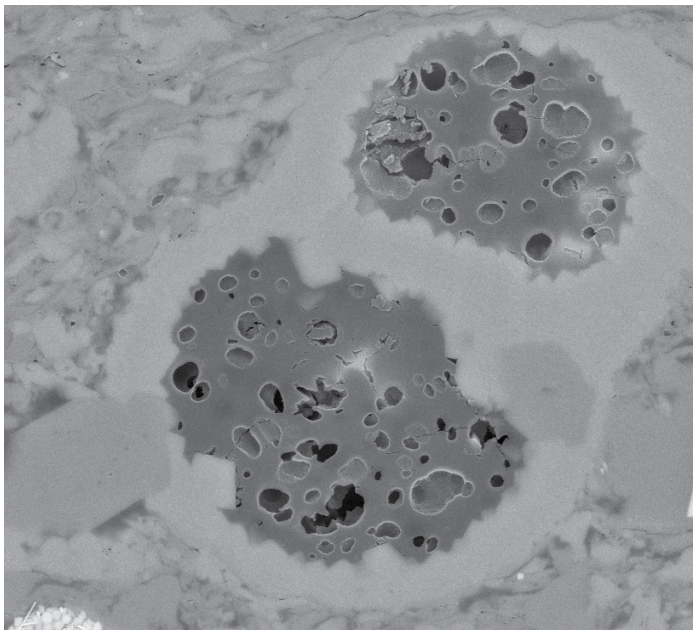
Since 2009, the primary focus of the Mudrock Systems Research Laboratory (MSRL) has been to characterize, model, and integrate core-based measurements to better understand mudrock reservoir systems. MSRL industry sponsors are provided access to annual meetings, core workshops, short courses, MSRL data sets, MSRL laboratories, and access to our team of scientists for specific research issues.

Research Thrusts

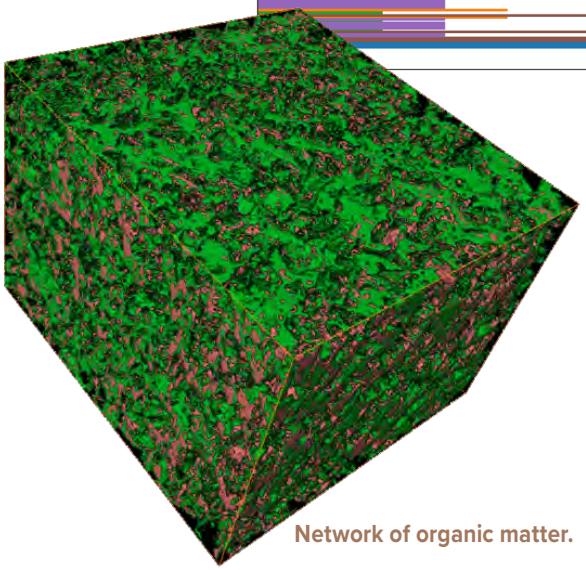
The MSRL has collected 14 years' worth of core-based measurements from major mudrock plays across the United States, China, and Argentina, and we apply this data to our multidisciplinary approach to better understand rock and fluid attributes that are important to mudrock systems.

- Facies characterization
- Fluid-flow modeling
- Permeability, porosity, and pore networks
- Rock and hydrocarbon geochemistry
- Wolfcamp, Bone Spring, Eagle Ford, Vaca Muerta, Barnett, Marcellus, Bakken, Pearsall, Haynesville, Austin Chalk, Woodford, and Yangchang





Scanning electron microscope (SEM) image showing organic-matter pores in bitumen filling the chambers of a foraminifer, Cretaceous Eagle Ford Group, Atascosa County, Texas.

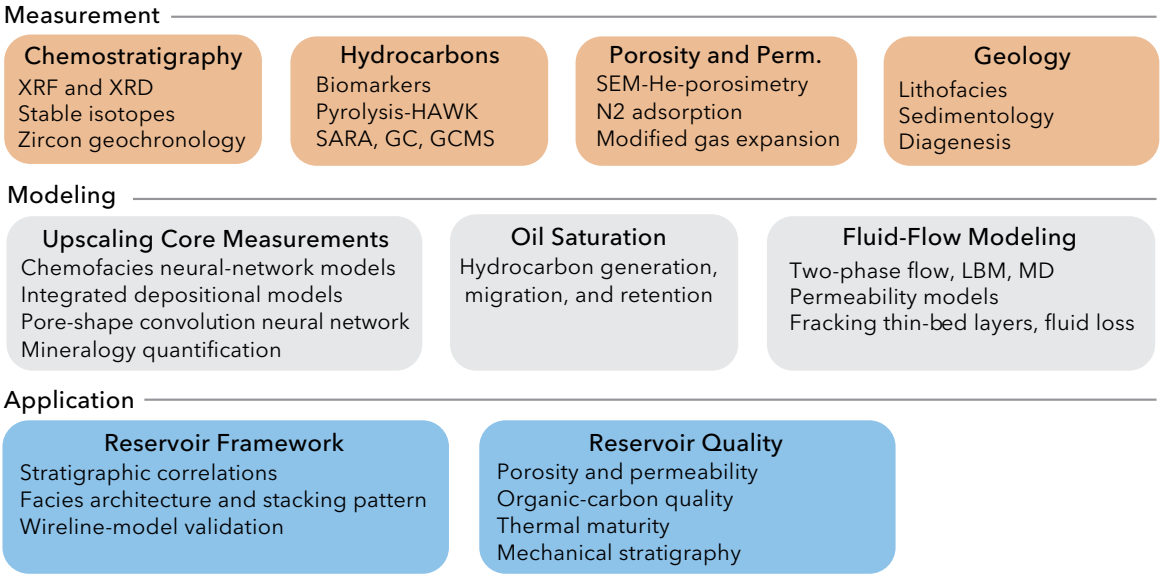


Network of organic matter.

Mudrock Systems Research Laboratory

Research Challenges

The MSRL challenge is to develop a better understanding of reservoir framework and reservoir quality through measurement and modeling. MSRL researchers take pride in the integrative multidisciplinary approach to characterize, model, and integrate core-based measurements to better understand mudrock reservoir systems. The MSRL workflow is designed to generate high-quality data, validate externally derived data sets, and understand key processes that control reservoir quality.



Membership

Consortium membership costs $50,000 annually. Members receive priority access to research data, interpretations, reports, and the following benefits:

1) **Spring annual meeting**
   Four days, including a one-day core workshop, two days of technical talks, and a one-day mudrocks short course
2) **Fall advanced short course**
   A one-day short course covering advanced methods in mudrock science
3) **Summer short course**
   This content varies. This year, we hosted a short course on new Python tools we are developing (CorePy) for visualizing core characterization and building neural-network models.
4) Access to data from the MSRL program, starting from 2009: all consortium reports, presentations, posters, extended abstracts, short-course materials, presentation videos, and published papers. Core characterizations include geochemical (high-resolution X-ray fluorescence, Pyrolysis, and biomarkers) and core descriptions.
5) Individualized sponsor-focused core workshops and short courses
6) Potential for sponsors to assist in research directions
7) Characterization/integration of donated/loaned cores
8) Access to MSRL researchers and our analytical facilities

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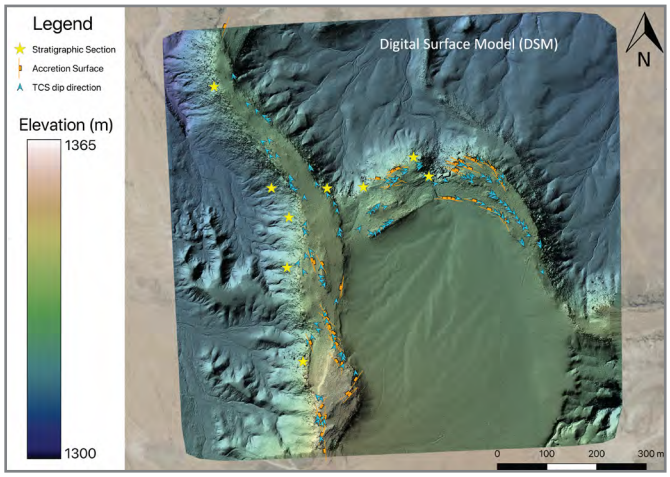
Quantitative Clastics Laboratory

Mission

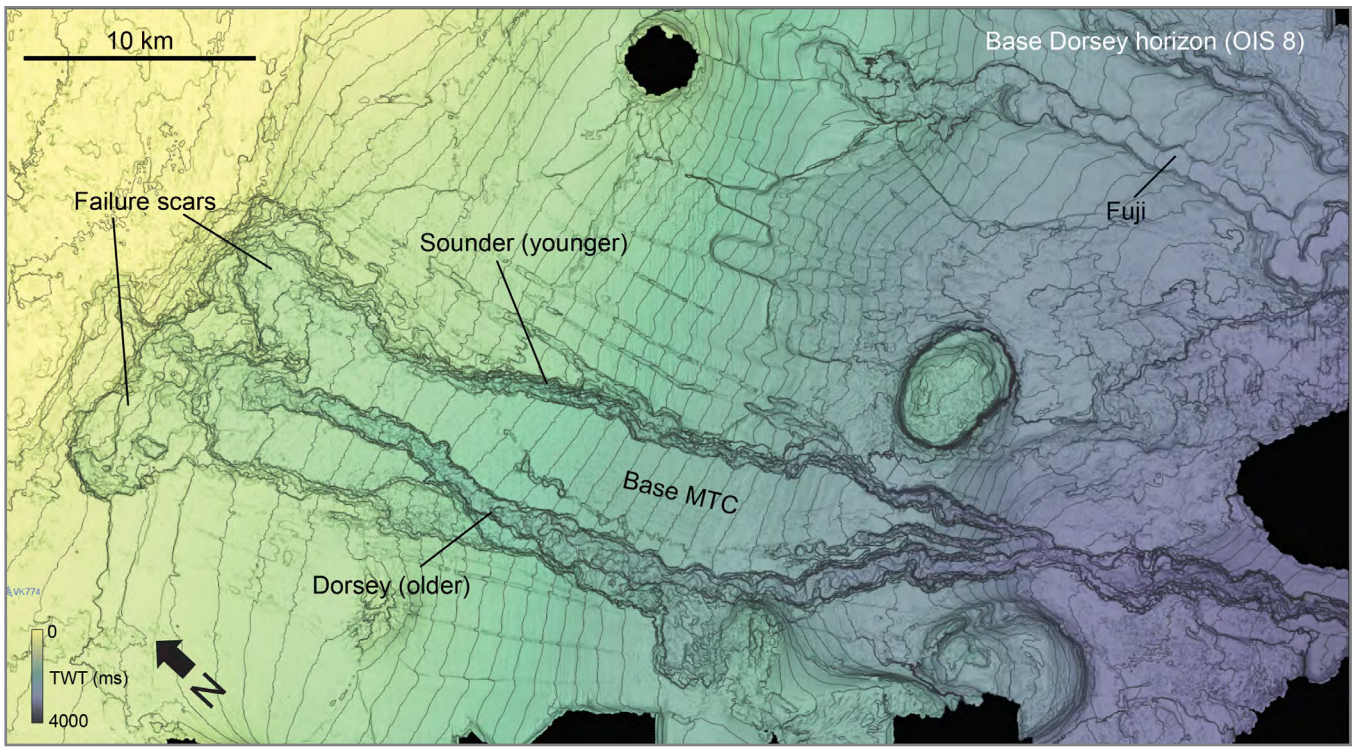
The mission of the Quantitative Clastics Laboratory (QCL) is to develop a predictive understanding of processes and controls on sediment transport and the stratigraphic evolution of depositional systems, with applications in reservoir characterization, modeling, correlation, and source-to-sink predictions for frontier exploration.

Research Thrusts

QCL researchers leverage the broad, world-class expertise of the Jackson School of Geosciences (JSG)—including collaborations with groups specializing in structural geology, Texas and Gulf of Mexico depositional syntheses, seismic interpretation, and thermochronology—to address key challenges in the exploration and development of natural resources. These challenges include the evaluation of reservoir presence and quality in data-limited frontier basins and the characterization of reservoir connectivity and heterogeneity. The QCL has unique clastic research consortia access to industry subsurface data, including global seismic-reflection data sets and Bureau core repositories.



Digital elevation model of exhumed Cretaceous channel belts in the Cedar Mountain Formation, by JSG student Cole Speed.

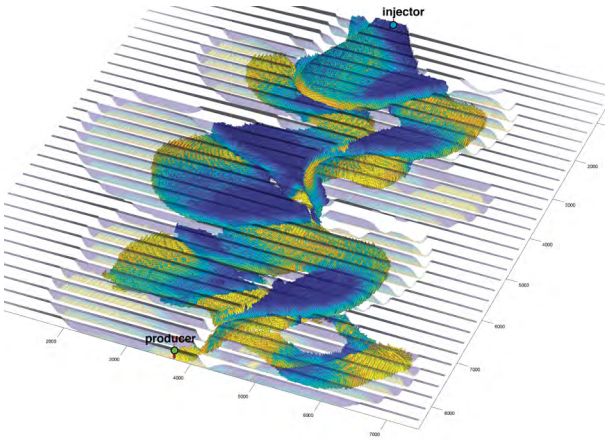


Structure map of a seismic horizon from the eastern Gulf of Mexico, showing the interaction between shelf-edge deltas, failures, and slope channels.

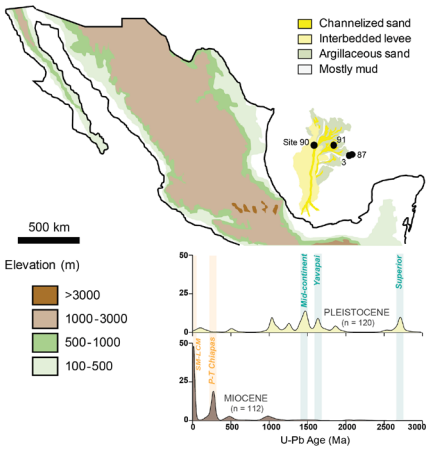
Quantitative Clastics Laboratory

Research Challenges

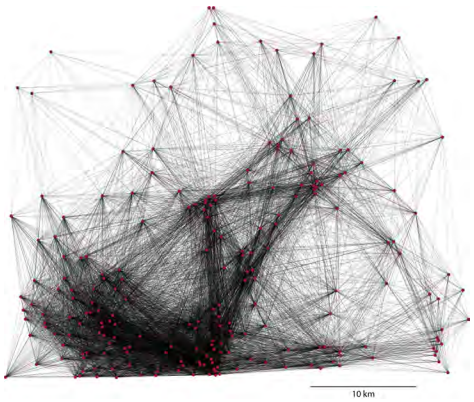
The QCL has two research themes: (1) reservoir-scale depositional system characterization, modeling, and flow simulation for a better understanding of processes that impact connectivity and heterogeneity; and (2) exploration-scale source-to-sink analysis to evaluate correlation, reservoir presence, and quality in the petroliferous Permian Basin and circum Gulf of Mexico. An exciting update to the QCL program is flow-diagnostics analysis of digital stratigraphic models for evaluating the effect of stratigraphic evolution and facies architecture on fluid flow during production.

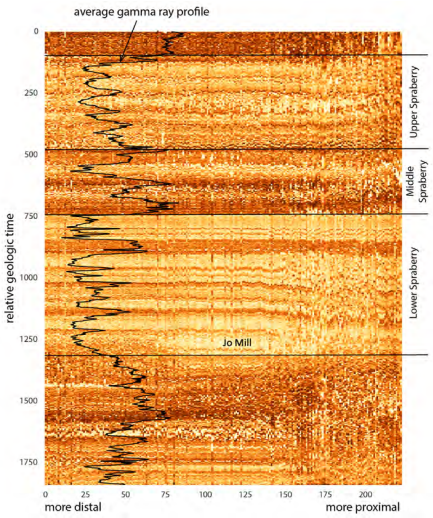


Flow-simulated reservoir model of a fluvial system that includes facies variability due to the presence of counterpoint bars.



Detrital-zircon geochronology to identify source areas for deep-water sands in the Gulf of Mexico.





Map showing well pairs used in correlation (left) and the resulting chronostratigraphic diagram for this part of the basin (right).

Membership

Each year's research calendar begins January 1 and runs through December 31. Multiple meetings, workshops, and face-to-face consultations with industry members are held annually. The QCL offers industry members unique access to JSG expertise, industry subsurface data, investigations of multiple scales of depositional environments and their interconnections, and an evolving quantitative database on clastic depositional systems architecture.

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www.beg.utexas.edu/qcl

Carbonate Reservoir Characterization Research Laboratory

Mission

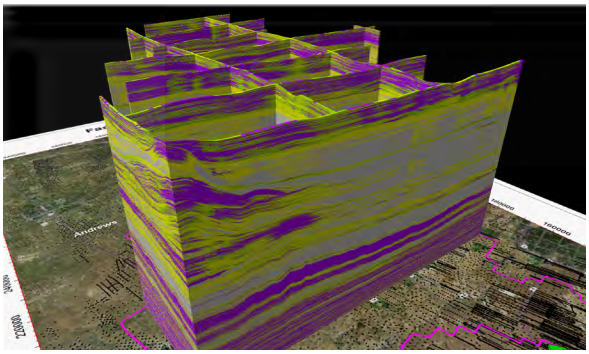
The Carbonate Reservoir Characterization Research Laboratory's (RCRL) mission is to use outcrop and subsurface geologic, geophysical, and petrophysical data from carbonate reservoir strata as the basis for developing new and integrated methodologies and concepts to explain and describe the 3D reservoir environment and to improve hydrocarbon recovery factors. In addition, the RCRL is dedicated to technology transfer and education and consistently offers state-of-the-art training, such as short courses, field seminars, in company reviews of assets, and extensive student supervision and guided research.

Research Thrusts

The RCRL approaches reservoir characterization through four main scales of investigation: (1) platform-to-basin-scale stratigraphy; (2) reservoir architecture, including both matrix and nonmatrix systems (e.g., fractures and paleokarst); (3) structural- and geomechanical-properties characterization; and (4) pore networks and their reservoir distribution. Research questions are developed using both subsurface data and outcrop analogs. The RCRL emphasizes quantifying observations so that its research is applicable to reservoir models and is valuable in providing predictive relationships and conceptual tools for reservoir characterization and play analysis.

Research Challenges

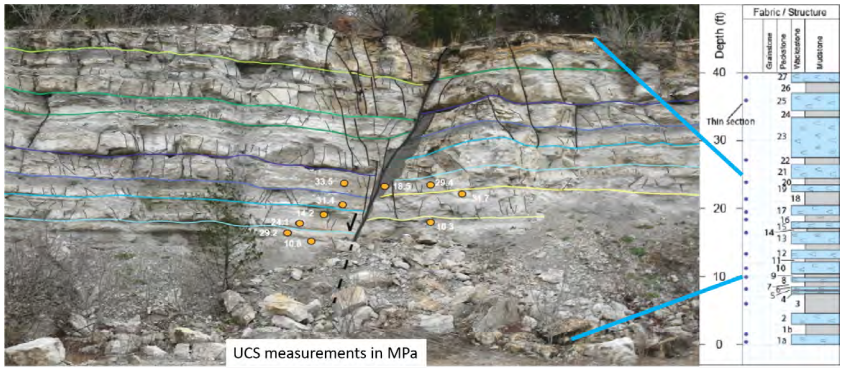
RCRL areas of investigation include Lower Permian shelf-to-basin stratigraphic and structural architecture of the Delaware and Midland Basins; Gulf of Mexico carbonate reservoir settings, pore systems, fracture character, and margin variability; Cenozoic carbonate platform systems, high-resolution stratigraphy, and structural configuration of shelf margins; fractured carbonate reservoir characterization in outcrop and subsurface analogs; origin and petrophysics of tight limestone and dolomite reservoirs; regional reservoir characterization of the Austin Chalk trend; and carbonate rock mechanics and acoustic-properties research.

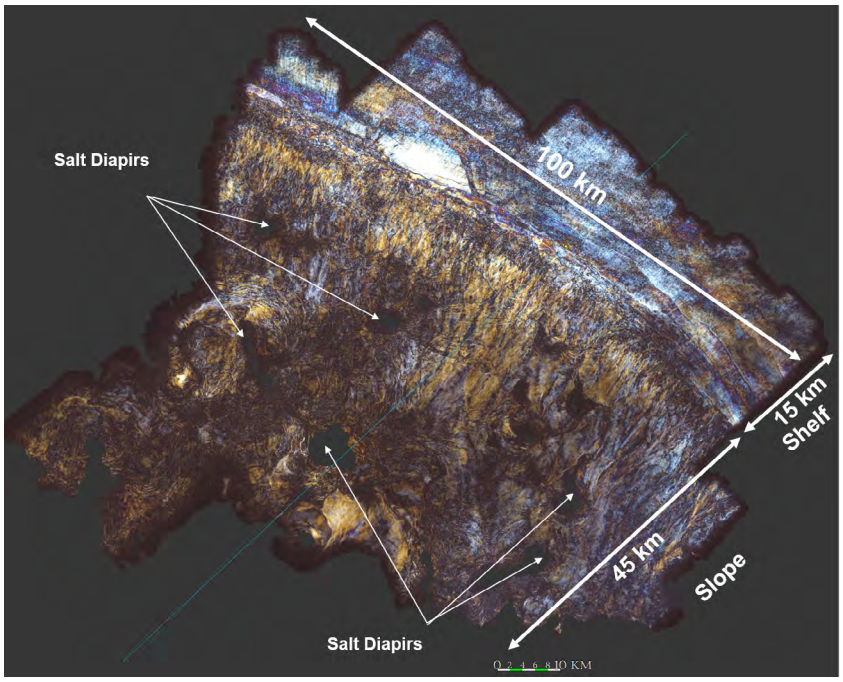


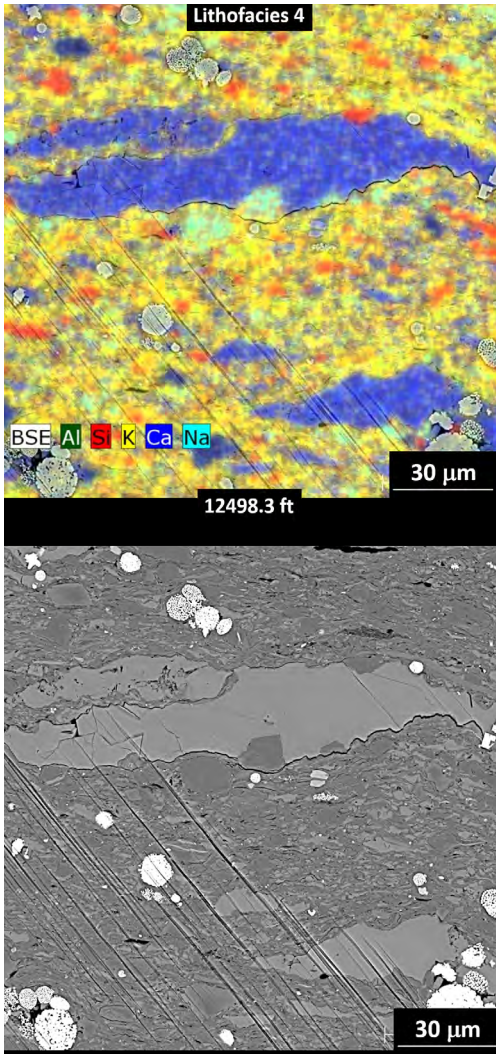
Carbonate Reservoir Characterization Research Laboratory

Membership

RCRL membership is $55,000 per year. Sponsors are encouraged to commit to a two-year agreement (at $50,000 per year) to better plan a longer-range research program.







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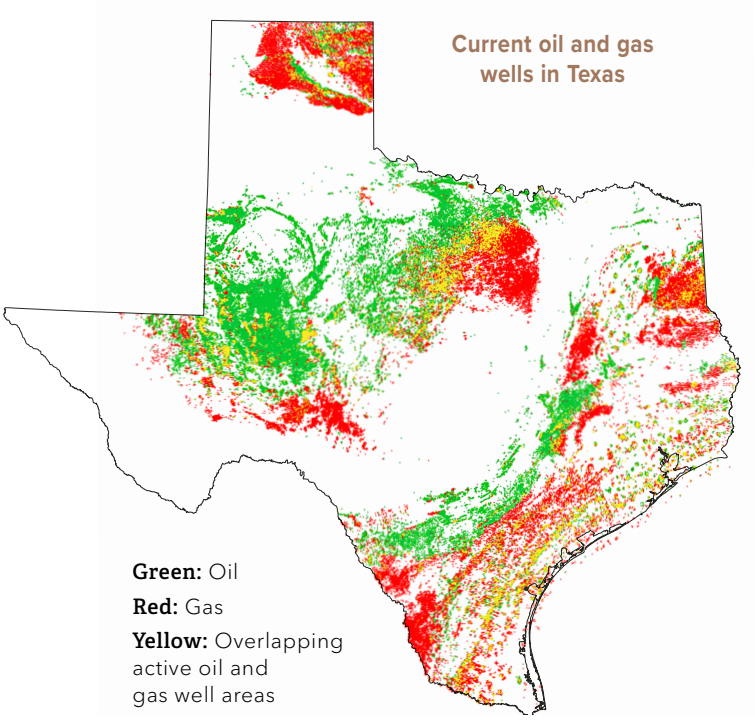
State of Texas Advanced Oil and Gas Resource Recovery

Mission

The mission of the Bureau's State of Texas Advanced Oil and Gas Resource Recovery (STARR) program is to conduct geoscience and engineering research to increase the profitability of earth resources within the State of Texas, including oil, natural gas, hydrogen, geothermal, and minerals, while encouraging responsible economic development and supporting education and environmental stewardship.

STARR carries out this mission by: (1) direct collaboration with operators in Texas who use our wide range of expertise; (2) pursuing detailed geological regional studies to identify factors controlling production; (3) undertaking integrated reservoir studies in collaboration with operators to advise on stranded oil and strategies to increase production from waterfloods and CO_2 floods; and (4) designing and formulating novel research projects associated with the broader gamma of energy resources in Texas.



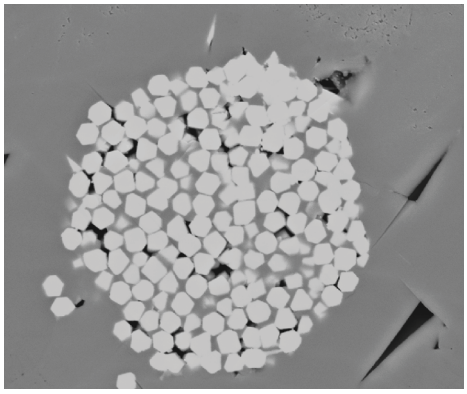
Research Thrusts

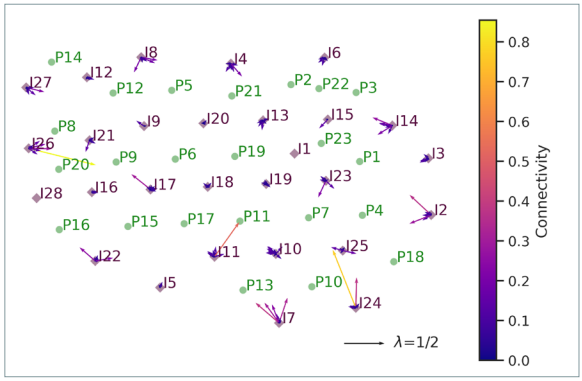
Research thrusts of the STARR program and ongoing technology transfer to operators in the Texas energy industry are focused on: (1) carrying out integrated geoscience characterization studies relevant to the oil and gas industry that span from regional to field scale (for both conventional and unconventional reservoirs); (2) developing improved oil recovery strategies, including optimization of waterfloods and CO_2 enhanced oil recovery (EOR); (3) developing data and analysis to support carbon capture utilization and storage at field scale, including strategies to increase CO_2 storage, assess the effectiveness of caprock seals, and develop monitoring strategies; and (4) conceptualizing and developing geological, geophysical, and engineering projects to support the energy transition in Texas, including hydrogen storage, in situ hydrogen generation, and geothermal energy.

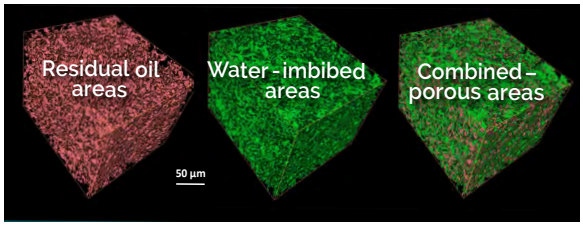
State of Texas Advanced Oil and Gas Resource Recovery

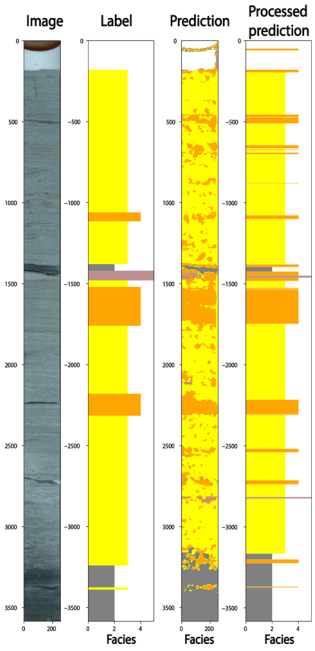
Research Challenges

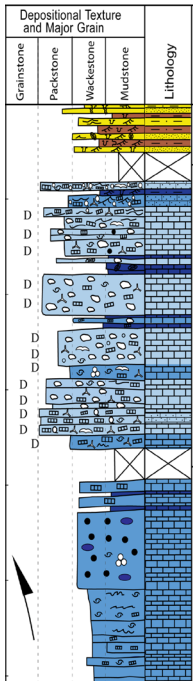
Challenges undertaken by the STARR team are wide and varied, ranging from explaining subsurface characteristics that control oil and gas production in Texas reservoirs to engineering challenges associated with identifying best EOR practices that have the potential for increasing oil and gas production in Texas oil fields. Recently, STARR challenges have expanded into the understanding of how Texas subsurface resources can be positioned to play a role in the ongoing energy transition, aiming at increasing the diversification and resilience of Texas' energy industries and its economy.

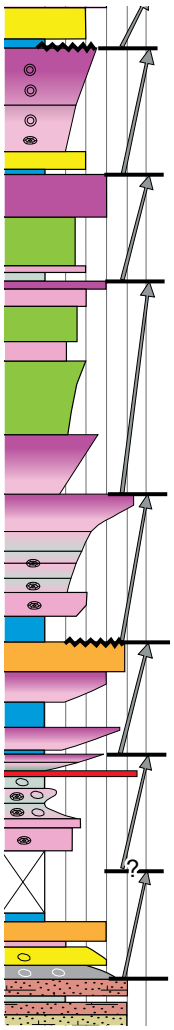












Membership

No costs are associated with participation in the STARR program, which is funded by the State of Texas, although matching support and willingness to facilitate publication of research results is encouraged. STARR partners receive a variety of technical products that include geological and geophysical interpretations that aim at explaining geological controls on reservoir quality and prospectivity, as well as engineering analyses that seek to improve resource recovery.

Contact

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Texas Consortium for Computational Seismology

Mission

The Texas Consortium for Computational Seismology (TCCS) is a collaboration between the Bureau and the UT Oden Institute for Computational Engineering and Sciences. The mission of TCCS is to address the most important and challenging research problems in computational geophysics experienced by the energy industry and to educate the next generation of research geophysicists and computational scientists.

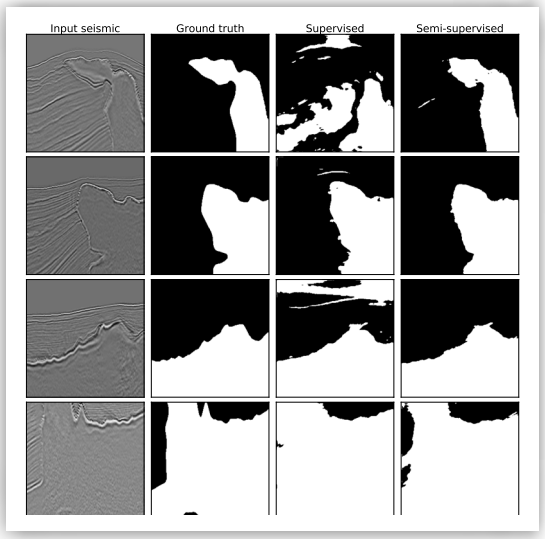
TCCS develops novel methods for seismic data analysis with the focus on both resource exploration and carbon capture and storage. Areas of research focus include optimizing data acquisition with simultaneous sources, automating seismic interpretation, increasing the resolution of seismic-reservoir characterization, and estimating subsurface properties using full-waveform inversion.

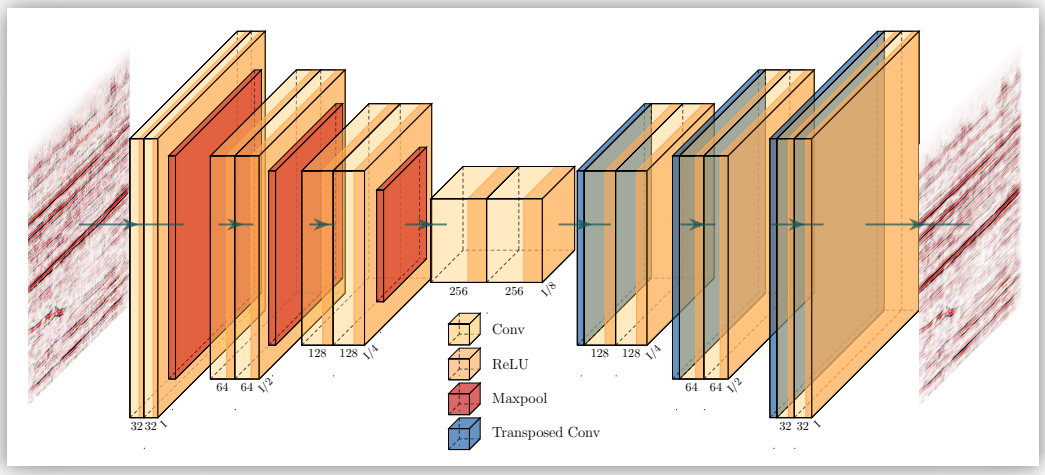
Texas Consortium for Computational Seismology

Research Thrusts

TCCS has pioneered new developments in several application areas:

- Deep-learning methods for seismic interpretation, including automatic detection of lithofacies and geobodies
- Deep-learning methods for seismic data processing and imaging, including noise attenuation, computational wave propagation, and least-squares seismic migration
- Optimal-transport methods for seismic full-waveform inversion
- Shaping regularization for improving acquisition and imaging with simultaneous sources
- Diffraction imaging for increasing the resolution of seismic imaging and reservoir characterization
- Seismic anisotropy and attenuation parameterizations for efficient imaging in complex media





Membership

Each year, TCCS delivers two written reports and presents its findings to sponsors at two research meetings.

TCCS publications follow the discipline of reproducible research: the results of all computational experiments are supplied with open-source software code that enables reproduction, verification, and extension of reported results.

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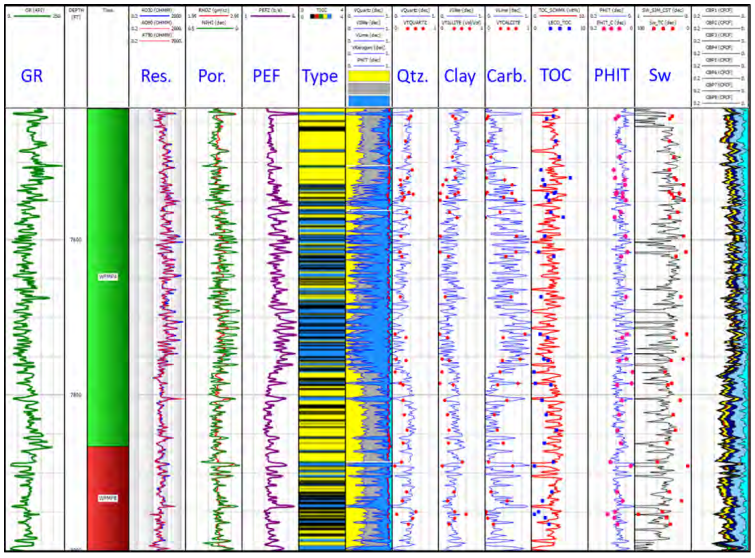
Tight Oil Resource Assessment

Mission

The Tight Oil Resource Assessment (TORA) program is an industry supported consortium that funds a multidisciplinary study of oil- and gas-producing horizons in the Permian Basin and other key U.S. tight oil and shale gas plays.

Our mission is to provide our stakeholders with reliable and up-to-date estimates, projections, models, and insights at the basin scale for the major U.S. unconventional plays by conducting innovative, integrated research of in-place resources and recoverable volumes, play–well economics, and production forecasts with their environmental implications. TORA produces detailed basin maps highlighting areas of highest productivity, in-place resources, and technically recoverable volumes based on a robust workflow to characterize the subsurface. TORA continually tests and develops new workflows and methods.

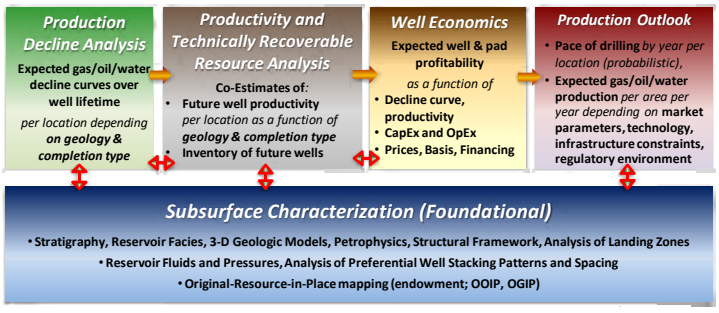


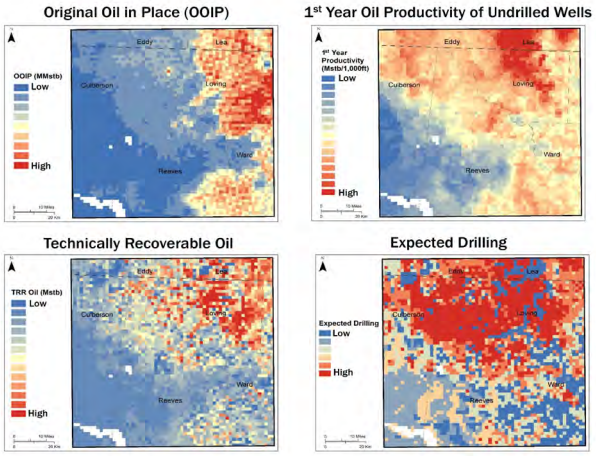
Core-calibrated petrophysics, Wolfcamp Formation, Permian Basin. TORA derives mineral and porosity volumes from abundant wireline logs using a thermal maturity-adjusted petrophysical inversion ("solver") approach combined with machine learning and rock typing. Development of such methods allows for better core-log calibration, enhanced understanding of tight rocks, and for building 3D rock property models at the basin scale.

Research Challenges

TORA aims to build integrated, unbiased, market-independent basin outlooks. Our team employs a novel study workflow utilizing 3D geocellular models. That workflow ultimately defines hydrocarbon recoveries, play sweet spots, economic viability, and play-wide production rates. TORA studies tight oil and gas formations, such as the Spraberry Formation, Wolfcamp Formation, Bone Spring Formation, Avalon Shale, and others, in order to produce unbiased and comprehensive results. What makes TORA unique is the basin-scale scope of investigation with in-place-resource mapping (example below) and predictions of productivity, profitability, and future drilling at a one square mile scale.

Research Work Flow





Details of play-wide maps at one square mile resolution.

Tight Oil Resource Assessment

Research Thrusts

TORA employs multidisciplinary research and a highly iterative resource-evaluation process. The key research disciplines are:

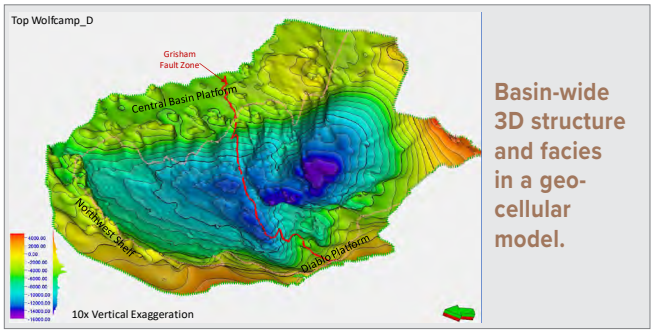
Geoscience: We interpret the stratigraphic framework using digital well-log correlations and core descriptions, resulting in a basin-wide 3D facies architecture based on in-house, detailed petrophysics. This framework is also used to calculate resource-in-place volumes. We use seismic-derived rock properties for sector-scale modeling.

Engineering: We model fluid flow and phase behavior to estimate in-place resources and recoverable volumes. We combine physics-based and data-driven modeling to project future production and estimate potential recovery of a well and the entire basin.

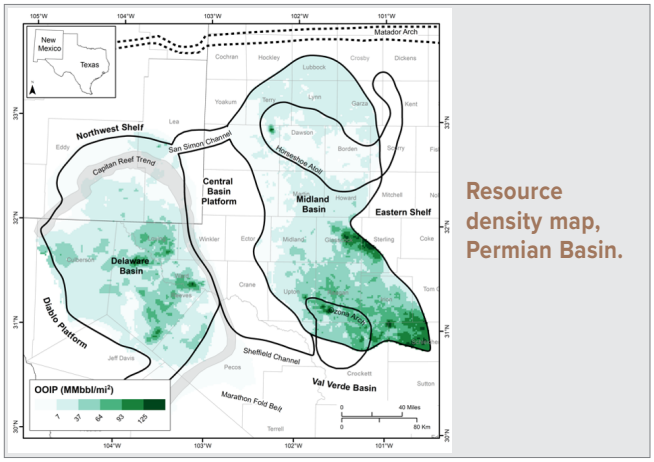
Data Analytics: We relate the productivity (per hertz foot) of existing wells to key subsurface and operational attributes and utilize this information to model the future productivity of all undrilled locations.

Economics: We develop the full range of expected production outcomes per well, technological and cost improvements, commodity prices, basis differentials (logistics), pace of drilling, well attrition, and lease accessibility, etc., in order to develop a view of profitability.

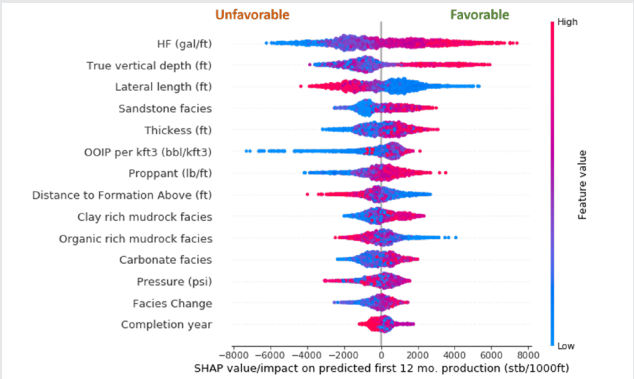
Arc-GIS: We use digital mapping to spatially link key geologic and operational practices to high productivity and resource-dense sweet spots.



Basin-wide 3D structure and facies in a geo-cellular model.



Resource density map, Permian Basin.



Feature analysis of control on LN first 12 months production, Permian Basin.

Membership

TORA membership is $60,000 annually, with contributions leveraged by State of Texas support and other sponsor funding. Benefits include detailed geologic, petrophysical, engineering, statistical, and economic reports and insights; semiannual meetings and conference volumes; basin-scale 3D geologic models; shapefiles of basin-wide maps for integration with your own mapping; consultations with the TORA team; and consortium-supported data sharing between sponsors and the Bureau to address specific technical questions. Our sponsors include established operators in the basins we study, nonoperating partners, and companies looking to acquire new acreage.

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Notes

Notes

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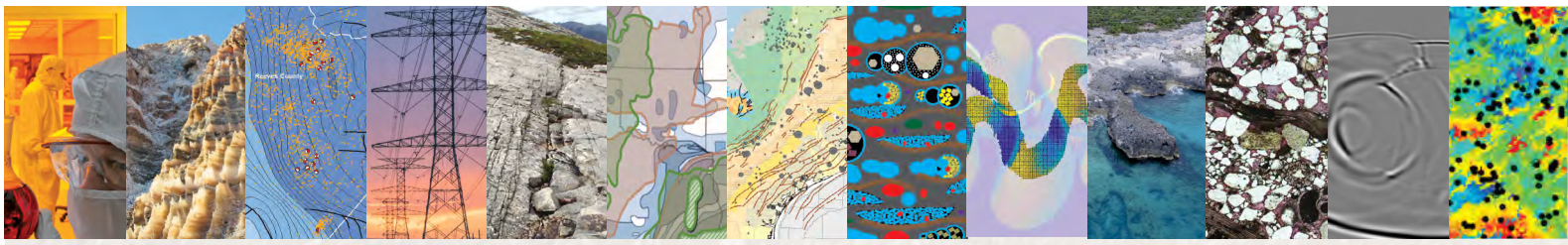

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