

RCRL Research Prospectus 2023



**Reservoir
Characterization
Research
Laboratory**



TEXAS Geosciences
The University of Texas at Austin
Jackson School of Geosciences
Bureau of Economic Geology

Carbonate Reservoir Characterization Research Laboratory (RCRL)

Mission

RCRL's 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 better explain and describe the 3D-reservoir environment, and to improve discovery, production, and storage of gas and fluid in carbonate rocks in the subsurface. In addition to this research mission, RCRL researchers are dedicated to technology transfer and education, continuously offering state-of-the-art training in short courses, field seminars, in-house reviews of selected assets, and extensive graduate student supervision and guided research.

Overall Research Goals

RCRL approaches reservoir characterization through three main scales of investigation, using both outcrop and subsurface datasets: (1) platform-to-basin-scale stratigraphy; (2) reservoir architecture and pore network distribution, including both matrix and non-matrix systems (e.g., fractures and paleokarst); and (3) structural and geomechanical properties characterization related to stratigraphic framework.

Membership and Funding

We invite your company to participate in the continuation of the RCRL Carbonate Reservoirs Research Program for 2023. In 2023, the annual RCRL Industrial Associates contribution to the program will be \$65,000 per sponsor per year. To encourage sponsors to commit to a 2-year agreement so that we can better plan a longer-range research program and reduce the time and effort in securing agreements, we offer a 2-year (2023 and 2024) rate of \$60,000 per year. Participating sponsors will sign a Memorandum of Agreement (MOA) for the 2-year commitment, payment being due in January of each year.

Membership Benefits

Industrial sponsors receive new research results at annual review meetings, in short courses, during mentoring activities, in prepublications, and on the continually updated, members-only RCRL website database (<http://www.beg.utexas.edu/rcrl/members/>). Our searchable website protects the investment in RCRL research and makes previously presented material easy to locate. The data area contains digital presentations, including archived video and annotated presentations, core workshop books, and fieldtrip guidebooks. Supplemental data, such as maps, core photos, porosity and permeability data, and digital outcrop reservoir models, are available through our password-protected database for RCRL members.

Interaction

We host an Annual Review Meeting and an associated Fieldtrip and Core Workshop, in addition to a 5-day training opportunity offered in the spring. These workshops are interactive (both in-person and remote), utilizing subsurface data, along with applicable outcrop analogues to emphasize applications of key elements that are important in understanding carbonate systems and their importance to hydrocarbon production. All presentations from our annual meetings and workshops are presented via Zoom and are recorded and available on our member website.

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RCRL Research Topics in 2023

Permian Basin Studies: Stratigraphy, Structure, and Reservoir Characterization

Stratigraphic Architecture of Reservoirs, Central Basin Platform

RCRL has access to large 3D seismic surveys provided by WesternGeco that cover the northwest corner of the Central Basin Platform (CBP). In this area, major production comes from the San Andres and Grayburg Formations (e.g., Eunice North Monument, Hobbs, Yates) as well as the Lower Clearfork (e.g., Abo, Drinkard). We are currently focusing on the San Andres–Grayburg interval in the northeast corner of the CBP. We will soon expand our study to deeper intervals, where the seismic integration may lead to better reservoir frameworks and enhanced strategies for enhanced oil recovery (EOR), water disposal, carbon capture and underground storage (CCUS), or hydrogen storage.

Permian Basins Deep-water Carbonate and Mixed Carbonate Siliciclastic Deposits (Channels, Fans, and Drifts)

Previous RCRL studies have shown that large fan complexes can be confidently mapped using our well-log and 3D seismic datasets in the Northern Delaware Basin. We will expand our mapping of the Wolfcamp A/B fan in the Midland Basin that we presented at the 2021 meeting and will leverage the RCRL 3D-seismic coverage from the Midland Basin. We will highlight and identify the differences in slope and basinal architecture between the Delaware and Midland Basins and their link to variation in regional external factors, such as slope morphology and angle, tectonic setting and size, and character of the various shelves surrounding the basins.

We also plan to take a more detailed look at the Bone Spring and Avalon intervals in the northeast Delaware Basin, where we have continuous 3D-coverage. We are incorporating detailed well-log, core, and seismic analysis to better characterize the architecture of these two prolific unconventional reservoirs and to assess what level of detail is possible using well logs alone, versus well-log and core data, versus integrated well-log, core, and seismic data. We are assessing the implications of these methods in creating accurate geomodels.

Late Wolfcampian and Early Leonardian Mixed Slope Outcrop Analogue Characterization, Sierra Diablo Mountains

This year we plan to continue work on the shelf-to-slope transition exposed in the Sierra Diablo Mountains. Our focus will be on the Upper Wolfcampian and Lower Leonardian strata (Wolfcamp A/3rd Bone Spring Formation-equivalent), where complex interfingering of carbonates and siliciclastic slope deposits are well exposed and traceable back to their equivalent shelf margins. This outcrop analogue work will shed light on the detailed architecture and stratigraphy of this important producing interval in the basin.

Delaware and Midland Basins Regional Structural Framework

Mapping of faults using our 2D- and 3D-seismic datasets will continue in the Delaware and Midland Basins. Building on previous work by RCRL and others, we will improve 3D-fault mapping across the basins using applicable 3D-seismic datasets. Several of our research projects focus on this fundamental characterization, including: (1) stratigraphic correlation of the Early Paleozoic through the Permian; (2) improved linkage of the shelf-to-basin sediment transport as related to structural uplift and basinal subsidence; (3) deeper knowledge of structural history of faults, as they could relate to both CCUS and potential ROZ production; and (4) awareness of areas having increased risk of induced seismicity related to saltwater disposal. This research effort is an ongoing effort; presentations of the data are made when Mesozoic Stratigraphy and Reservoir Characterization.

One long-term RCRL goal in Mesozoic studies is to investigate the large-scale architecture of the Upper Jurassic through Lower Cretaceous platforms in the Gulf of Mexico (GOM) using available seismic data, well logs, and cores. Previously we determined significant regional variability in the style of shallow-water carbonate factories and associated architectures around the GOM. We will continue to pursue this characterization in several studies in 2023.

Mesozoic Stratigraphy and Reservoir Characterization

Upper Jurassic and Lower Cretaceous Shelf-Margin Synthesis in the Gulf of Mexico

In 2023, as part of our long-term plan to investigate the large-scale architecture of the Upper Jurassic to Lower Cretaceous platforms in the GOM, we will focus on the Upper Jurassic Smackover Formation. We will integrate the multiple cores that RCRL has studied in past years with new publicly available cores and synthesize them with other sources, such as well-log and seismic data. Our goal is to provide greater insight to the regional controls on Smackover facies variability and distribution at the regional GOM scale.

Using cores and seismic studies, RCRL has amassed comprehensive knowledge of the lowermost Cretaceous carbonate margin around the GOM. We are interested in collaborating with our sponsors to potentially start a comparative study of the regional architecture and distribution of Berriasian to Barremian carbonates system with age-equivalent carbonate strata and carbonate systems worldwide. This proposed study is motivated by renewed exploration interest in age-equivalent carbonates along continental margins globally. It will depend on interest and availability of supplemental data from sponsors and public sources.

Cretaceous (Albian) Shelf- to Intrashelf-Basin Exposures, Facies Patterns, and Structure/Fracture Models, Sanderson Area and Southwest Texas

We are exploring areas of southwest Texas along the Rio Grande, where exceptional exposures crop out along the canyon walls of the Rio Grande, within Big Bend National Park, and in other canyons. These outcrops provide seismic-scale views of the subtle intrashelf basin framework. Integration of digital technology and detailed section measuring and facies mapping along with structural analysis will build on the work being conducted by RCRL along the Pecos River Canyon and associated road-cut exposures.

Upper Cretaceous Unconventional Chalk Reservoir Studies

Regional Austin Chalk Synthesis and Production Behavior Study

RCRL's regional Austin Chalk Project researchers have presented results on its finding for several years and will continue to collect data from the onshore northern Gulf of Mexico from the Texas-Mexico border to central Louisiana. Integration of numerous cores descriptions will be used to delineate regional lithofacies patterns, especially the distribution of the organic-rich facies that are in part source rocks for the Austin Chalk. We will also integrate our large database of Rock Eval and HAWK data into this regional study. Furthermore, an analysis of gas-oil ratio (GOR) changes by region will be used to elucidate key information about the geologic controls on reservoir-production behavior.

Characterization of the Outer-Shelf Del Rio Formation as a Tight-Chalk Play

Characterization of the Del Rio Formation is being conducted to determine if the formation is a potential tight-gas play along the outer shelf in South Texas. We have obtained several strategically located cores that we will analyze for pore networks and other rock characteristics. Charging potential will be a crucial factor in defining the play. We also intend to document the style and quality of traps needed to create economic reservoirs.

Carbonate Debrite Reservoirs Associated with Upper Cretaceous Volcanic Mounds, South Texas

Carbonates associated with volcanic mounds in the Austin and Anacacho Chalks in South Texas are producing reservoirs that are poorly known. Many potential reservoirs in this area are not yet discovered or defined. We have found that the carbonates can occur on the top of the volcanic mound platform (i.e., sand shoals), around the shallow-rim of the volcanic mound (i.e., shoals and barrier reefs), or at the toe-of-the-slope of the mound (i.e., debrites). We are integrating a 3D-seismic volume and six cores from the Elaine Field in Dimmit County, where production occurs from the carbonates associated with the volcanic mound. This project is a joint study with both RCRL and STARR research programs.

Cenozoic Studies

Extracting and Quantifying Miocene Margin Seismic Facies, NW Shelf of Australia

RCRL has used a large collection of 3D-seismic datasets from the Northwest Shelf of Australia to illustrate the regional variability in the complex distribution and architecture of the Miocene carbonate platform along this continental margin. In 2023, we plan to focus on a few key surveys along the platform margins to extract 3D geobodies of various depositional environments and compare this morphometric analysis with equivalent modern datasets. The goal of the study is to evaluate the presence of morphometric trends along a reefal margin that could help predict facies variability and dimensions in area with less extensive or poorer quality seismic coverage. These concepts will aid in understanding distribution of reservoir facies.

Virtual Reality Outcrop Models, Virtual Field Trips, and Digital Analogues

The RCRL team will continue our efforts to develop and optimize virtual reality field trips, digital outcrop models, and other analogue models for our sponsors. Our plan is to make key areas available as digital models (OBJ or LAS files), interpreted 3D models (VRGS), and Virtual Reality sessions (VRGS, RCRL VR, and other environments), and to begin to catalogue video and VR field trips. Some or all of these data types will be made available in the following areas:

- Victorio and Apache Canyons: Wolfcampian–Leonardian strata from the Sierra Diablo Range
- Leonard Mountain, Glass Mountains: Leonardian stratotype section
- Lawyer Canyon, Algerita Escarpment: San Andres reservoir analog
- Pecos River Canyon: Exposures of Albian-age carbonate depositional systems
- South Texas Carbonate fault-related fracture models
- Dry Canyon, Pennsylvanian exposures of the Sacramento Mountains
- Faulted Yeso–San Andres–Grayburg Formation, Brokeoff Mountains

Our goal is to continue to generate 3D virtual-reality fieldtrips, integrating digital outcrop models with geological interpretations, core descriptions, subsurface models, and documentary materials from RCRL's database of key analogues.

Sponsor Activities in 2023

Fundamentals of Carbonate Reservoirs Video Series: In 2023, a series of recorded lectures that comprise the essential elements of reservoir characterization will be released to RCRL members. This video series will focus on fundamentals of carbonate systems, carbonate depositional systems, carbonate sequence stratigraphy, carbonates in seismic, the role of structure in carbonate reservoirs, fracture modeling in carbonates, and geocellular modeling of carbonate reservoirs.

2023 Spring Core and Field-Work Session: A two-day core workshop highlighting cores from key integrated datasets will be featured, illustrating various carbonate reservoir age, style, and setting. In addition, key cores that illustrate Austin Chalk lithofacies and stratigraphic architecture will be presented followed by a 2-day Austin Chalk field trip in Central Texas.

Tentative 2023 Fall Field Trip: Key outcrops of Permian Basin analogues that will highlight important views and observations, including:

- Syntectonic Wolfcampian and Leonardian margins and slopes in the southern and western part of the Delaware Basin (Glass Mountains and Sierra Diablo).
- Cutoff Formation (Avalon time-equivalent) deep-water carbonate mudstones with heterogeneous mass transport complexes and organic-rich mudstone facies (Rest Area Gully)
- San Andres reservoir flow-unit-scale outcrop analogues (Lawyer Canyon)
- Upper San Andres shelf-to-basin clinoforms (Last Chance Canyon and Wilson Canyon)
- Well-developed ooid grainstone tidal bars and intercalated siliciclastic units in Guadalupian mixed clastic-carbonate ramp cycles (Shattuck Escarpment)
- Interplay between deep-water siliciclastics and carbonates at the Guadalupian basin margin

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- Debrite complexes and mass-transport complexes of the Bell Canyon/Lamar system (McKittrick Canyon)
- Syndepositional faulting and graben development at the shelf margin in Capitan Reef equivalent shelf strata (Rattlesnake Canyon and Walnut Canyon).

RCRL Database Updates

- Searchable Catalog of RCRL Presentations and Extended Abstracts
- RCRL Core Workshop Database
- Austin Chalk Core Properties Database
- Reservoir Properties Database of Gulf of Mexico Carbonates
- Conversion of Digital Outcrop Catalog to searchable ArcGIS (forthcoming 2023)

Industrial Sponsors

The RCRL program has functioned continuously since 1987, maintaining strong company sponsorship each year. In 2022, these 18 companies supported our research initiatives:

Financial-Contributor Members



Additional support came from the following 10 companies:

Software and Data Contributors

Fairfield Geotechnologies	TGS	Golder	IHS Markit	Velocity Databank
Ion	Eliis	Halliburton	Schlumberger/WesternGeco	GeoStar Seismic

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Research Group

Principal Staff

Dr. Xavier Janson, Senior Research Scientist, Principal Investigator
Dr. Christopher Zahm, Research Scientist Associate
Dr. Charles Kerans, Goldhammer Chair of Carbonate Geology
Dr. Robert (Bob) Loucks, Senior Research Scientist
Mr. Robin Dommissie, Research Scientist Associate
Mr. Josh Lambert, Research Scientist Associate

Associated Staff

Ms. Kelly Hattori, Research Scientist Associate, Stratigrapher
Dr. Tingwei ("Lucy") Ko, Research Associate, Geochemist
Dr. Hongliu Zeng, Senior Research Scientist, Seismic Analysis
Mr. Evan Sivil, XRF and Isotope Lab Manager
Dr. Sheng Peng, Research, Research Associate
Mr. Jerry Lucia, Retired Emeritus

RCRL collaborates closely with the Quantitative Clastics Laboratory (QCL) at the Bureau of Economic Geology (BEG) in the characterization of mixed carbonate/siliciclastic slope to deep-water systems in the Permian Basin and in Australia. We also collaborate with BEG's STARR-CCUS consortium on reservoir characterization projects and with the Center for Integrated Seismicity Research (CISR) for improved structural characterization in the Permian Basin.

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Graduate Students

RCRL is proud of the research accomplishments of our past and current graduate students. Most of our graduated students are now working in industry research, production, and exploration. Our recent or current students and their research projects include:

Shawn Fullmer (Ph.D., May 2023) - Quaternary (Mid-Late Pleistocene--Holocene) Carbonate Geomorphology of the Bahamas-Caicos Archipelago: Carbonate Factory Response to Sea-level and Climate Change. ExxonMobil and DGS-Goldhammer Chair of Geology funding, RCRL contributor.

Charlie Zheng (Ph.D., May 2023 - Two Dissertation Topics under Consideration) – Dissertation Topic 1: Benthic Oxygenation History of South Texas During Austin Chalk Group Deposition: An Integrated Ichnologic, Sedimentological, and Geochemical Study. Dissertation Topic 2: Paleoecological and Paleoceanographic Reassessment of Intrashelf Basin Formation of the Upper Albian Devils River–Salmon Peak Formations, Maverick Basin, South Texas. DGS, STARR, and RCRL funding. GSA student research grant and SEPM student research grant funding.

Mohammed Fallatah (Ph.D., May 2023) - Cretaceous Stratigraphy of Saudi Arabia at the Arabian Plate Scale. Saudi Aramco funding and RCRL contributor. Scarlett Hsia (Ph.D., May 2023) – Highstand Constraints on the Whale Point Succession and MIS 5a GIA Trends in the Western Atlantic. Funded through GSA, NSF-GRFP, and DGS. RCRL contributor.

Kyle Fouke (Ph.D., May 2024) – Architecture and climatic record of the Last Interglacial Coral-algal Reef Complexes, Bahamas-Caribbean region. DGS and Goldhammer Chair of Geology funding, RCRL contributor.

Josh Malone (Ph.D., May 2026) – Pennsylvanian Shelf-to-Basin Architecture, Darwin Basin, Nevada, California, and Permian Basin, TX, RCRL Funded and Contributor

Invitation

Staff and students of the Reservoir Characterization Research Laboratory cordially invite you and your colleagues to contact the Principal Researchers to join with us in these and other important research activities.