Early Permian shelf-to-basin syntectonic to early post-tectonic stratigraphy of the Delaware and Midland Basins

RCRL has more than 30 years of research experience within the Permian Basin and with this longevity in mind, we recognized that it is essential to understand the shelf-to-basin connection. The Wolfcampian through Guadalupian sedimentology of the Delaware and Midland Basins is diverse and dynamic. The RCRL group is uniquely positioned to provide innovative research using key outcrop exposures that are held by private land owners. In addition, we bring decades of knowledge and understanding of the Permian Basin to bear upon this very important problem of platform-to-basin correlation. This area of research will continue to be a significant contribution to the 2019 program as highlighted by individual projects below.

Stratigraphic architecture of Wolfcampian to Guadalupian platforms, shelf margins, slopes and basin fill, Glass Mountains to Southern Delaware Basin

We will continue the investigation of the platform-to-basin architecture of Early Permian outcrops in the Glass Mountains, including the development of an improved high-resolution stratigraphic framework that includes the influence of tectonic elements in the southern Permian Basin. In addition to the outcrop mapping effort, we will expand the study into the subsurface of the south Delaware basin by tying the outcrop stratigraphic architecture to a few existing cored wells and numerous wireline-logs. This study aims to increase our knowledge of carbonate platform evolution and the associated potential reservoir distribution associated with compressional tectonic and foreland basin evolution and should be of interest for companies that produce reservoirs or explore in similar settings. The outcome of this work will be beneficial to companies that work unconventional reservoirs in the southern Delaware Basin and that are interested in understanding the origin and architecture of the shelf-sourced sediments being delivered into the basin

Wolfcampian to Guadalupian shelf-to-basin framework of the Midland and Delaware Basins

In response to increased activity in the Midland Basin (MB) and adjacent Central Basin Platform (CBP) we plan to work with operators in the North Cowden-Midland Farms-Mabee area using 3D seismic, wireline-logs, and core data to modernize the stratigraphic framework. A complex reciprocal pattern of clastic-carbonate sedimentation is closely parallel to that developed from the studies that incorporated outcrop to Delaware Basin subsurface data. This model has been partially implemented by member companies and we plan to further document this framework and apply better understood Delaware Basin terminology in the cases where we can make these comparisons.

Integration of core facies and stratigraphic data with wireline-log and seismic interpretations will aid this effort. Other groups, including Pioneer and Apache, also have substantial experience in this part of the basin that will provide steering of our stratigraphic framework as it develops. We have begun the process of integrating core data into this framework and will continue this work at both the Guadalupian and Wolfcampian levels. Addition of expertise from Greg Wahlman will aid in generating biostratigraphic control. Depth conversion of seismic data will permit greater integration of the seismic with wireline-log and core data.

Characterization of mixed carbonate-siliciclastic slope to basin deposits in the Permian Basins and outcrop analogs of the Sierra Diablos and Ely-Bird Spring (EBS) Basin in SE California

This project aims at investigating the architectural elements of a mixed siliciclastic and carbonate slope during the Early Permian (Wolfcampian to Leonardian) around the Permian Basin. This study will be supported by the numerous core available at the BEG, wireline-logs, and regional 2D and 3D seismic lines. Our goal is to link process-based sedimentology of slope deposits to slope architectural elements and shelf-to-basin attributes. There is a wide range of shelf-to-basin profile around the Permian Midland and Delaware Basins ranging from a shallow slope on the Eastern Shelf to steep structurally controlled slope on the west side of the Central Basin Platform. The shelf-to-basin morphology, including inherited topography from tectonic features, is thought to be the primary control on the distribution of the slope architectural elements and slope facies on the slope. We will incorporate seismic datasets available to RCRL as well as key outcrop analogs including outcrops in the Sierra Diablo area and potentially outcrop analogs in the EBS basin in California. As the Lower Permian has become an important unconventional resource in both basins, we propose that a better understanding of the regional architecture of the slope will be beneficial for the exploration and production of the Wolfbone and Wolfberry plays.

3D fault framework within the northern Midland and Delaware Basins and implications for Early Permian synorogenic deformation and deposition

Using the Fasken Ranch and Red Tank 3D seismic volumes along with previous RCRL and BEG studies, a comprehensive examination of synorogenic deformation and deposition will be conducted. The goal of this research effort is to better constrain (1) 3D fault geometry and movement history; and (2) map the impact of the fault movement on synorogenic deposition. Constrained timing of the fault movement history will be tied to regional outcrop analogs with the goal of providing a well-documented fault movement and depositional history of the Early Permian in select locations within the basin. This characterization is useful to the overall correlation of Wolfcampian to Leonardian shelf-to-basin profiles and will aid in the prediction of carbonate- versus siliciclastic-rich debris flows in the basin.

Integrated reservoir characterization geocellular models at field scale of the Fasken Ranch and Red Tank 3D seismic areas.

The Fasken Ranch high-resolution 3D geocellular model currently combines 3D seismic, well logs, faults, core interpretations and injection and production data. In 2019, additional structural and stratigraphic interpretations will be incorporated into the model. The goal of this research is to create an integration environment used to compare existing operational models and to serve as an integration tool for the platform and facies architecture for Wolfcampian, Leonardian, and Guadalupian platform-basin systems. Following the time-depth conversion step, a similarly integrated geocellular model will be constructed for the Red Tank 3D seismic study area.

Micropetrography and pore network characterization of Wolfcampian, Bone Spring and Avalon intervals in cores

Previous studies of carbonate mudrock systems has revealed a diverse, yet systematic development of nano- to micropore systems that are critical to hydrocarbon production within unconventional reservoirs. By using a cadre of tools including SEM imagery, ion-milled sample preparation, and blue-fluorescent dye, the nano- and micropore network is characterized. Nano- to micropore networks within the Wolfbone, Wolfcamp, and Avalon units are being characterized in a variety of cores from the Delaware and Midland Basins. To date, we have completed micropetrography for several cores and are developing concepts about micropetrography, organic richness of facies, and pore networks.

Austin Chalk lithofacies, mechanical and geochemical stratigraphy, fracture characterization, source rock evaluation, and reservoir performance characterization

Austin Chalk is an integral part of the unconventional hydrocarbon system in the Texas and Louisiana part of the Gulf of Mexico and are also genetically and temporally linked to the prolific oil-rich Eagle Ford system. To gain a better understanding of the evolution and demise of these Gulf of Mexico drowned-carbonate platform successions, the RCRL, with cooperation of the BEG STARR Program, has undertaken a multipronged approach to the study of the Austin Chalk. Depositional patterns will be reviewed using existing and new data (i.e., measured sections, core descriptions, wireline logs) along a proximal to distal transect so that changes in facies, anoxic events, and productivity trends can be examined, along with organic richness. We have a large core data set ranging from central Louisiana to the Mexican border.

Lithofacies and source rock evaluation characterization of Austin Chalk in Texas and Louisiana

A stratigraphic framework will be coupled with collection of basic data on cores of the Austin Chalk, including X-ray fluorescence, spectral gamma, minipermeameter, and velocity profiles. Petrology, petrography, and SEM analysis will be collected to explain grain and pore types

which are fundamental data that will be used in combination with the associated data. In conjunction with the BEG-STARR program, 3D seismic analysis of fault and fracture corridors and their relationship to production trends will ultimately tie together stratigraphic and structural frameworks, along with petrophysical data and reservoir productivity, so that a more complete understanding of production trends and fairways within this Upper Cretaceous system can be achieved. Will also address the organic-matter-rich/organic-matter-poor cycles in the Austin Chalk as to their origin and distribution.

Geochemical and mechanical stratigraphy of the Austin Chalk and transitional Eagle Ford

We will continue to pursue the relationship between lithofacies, pore types, geochemical properties, mechanical stratigraphy, and natural fracture development in the Austin Chalk and transitional Eagle Ford. We will work in conjunction with the MSRL group for improved geochemical characterization and seek to understand the correlation between chemical signatures and the regional lithofacies patterns. We believe that understanding the regional stratigraphic and geochemical patterns can improve predictability of reservoir behavior and aid in the development of a robust mechanical stratigraphic framework to aid in natural and hydraulic fracture characterization.

Natural fracture impact on Austin Chalk reservoir performance

Understanding the impact of natural fracture development on reservoir performance in the unconventional Austin Chalk and transitional Eagle Ford is an important step toward linking descriptive characterization to predictive reservoir development. In 2019, the RCRL group will be combining efforts with integrated teams at the BEG and key sponsors to improve the understanding between geologic characterization, including lithofacies, geochemical and mechanical stratigraphy and natural and hydraulic fractures, and reservoir performance. This will be a multiyear project.

Mechanical stratigraphy and fracture characterization of the Austin Chalk in outcrop analogs

In 2019, the RCRL group will be characterizing classic Austin Chalk outcrop exposures for improved characterization of the relationship between rock properties, mechanical stratigraphy and fracture development. We intend to add a higher resolution of characterization to better understand natural fracture development and the expected response of these properties to hydraulic stimulation in the subsurface. The outcrop affords the ability to study the subtle, sometimes centimeter-thick bed boundaries that control the fracture development. Our intent is to develop a strong enough catalog of outcrop exposures to lead a multiday field trip to highlight key learnings from this characterization.

Gulf of Mexico Carbonate Reservoir Settings, Margin Variability and Pore Systems

RCRL is developing a regional synthesis of Lower Cretaceous carbonate platform architecture around the Gulf of Mexico Basin. This multiyear project aims at documenting the variability of stratigraphic and structural architecture at the regional scale for the Lower Cretaceous shelf-margin systems with expansion of the well-developed framework in Texas to encompass the entire GOM basin. In addition, we will be exploring the high-resolution intrabasin variability of facies distribution and cycle architectures within the Albian-age ramp that prograded into the Fort Stockton embayment within the Maverick Basin of Texas as well as continuing the characterization and paleogeographic placement of a recently identified Albian marine microbialites. Finally, the realization that numerous limited offset faults exists within the Laramide foreland is an important finding and our 2019 research will examine the influence these fault zones have on Mesozoic and Paleozoic hydrocarbon production.

Regional synthesis of Lower Cretaceous platform architecture around the GOM

The RCRL has worked extensively on the Lower Cretaceous platform around the GOM over the past two decades. In particular, our recent work has focused on the Aptian of Central Texas and the response of carbonate systems to global oceanic events (OAEs). Our work on the earliest Cretaceous (Berriasian and Valanginian) has defined the Calvin Limestone, a new carbonate system, that is several thousand feet thick at its shelf margin. We published these result January 2017. RCRL researchers have investigated a number of Albian platforms around the GOM including those in Mexico, Arizona, Texas, Florida, and Bahamas in both outcrop and subsurface. In 2019, we will continue to summarize previous results and combine new analyses of subsurface data into a regional synthesis of the stratigraphic architecture of the Aptian and Albian platform around the GOM. Within this framework we will correlate the various local stratigraphic units into an updated version of the regional stratigraphic framework proposed by Kerans and Loucks. The synthesis will also include the compilation of quantifiable parameters on the morphology and evolution of the platform architecture. The ultimate goals are to provide understanding of the various global controls (e.g., oceanic anoxic events, eustacy), regional bathymetric controls (e.g., tectonics, subsidence, antecedent topography and paleogeography), and local variability in the stratigraphic architecture. We believe this framework will improve our understanding of the distribution of petroleum systems and associated reservoirs of the Lower Cretaceous around the GOM.

Characterization of a Structurally Complex Lower Cretaceous Carbonate Platform, El Doctor, Central Mexico

The characterization of the world-class outcrop of the Albian-Cenomanian(?) El Doctor platform is a field-oriented research project that is being led by Abdulah Eljalafi under the supervision of Charlie Kerans and with the cooperation of faculty at the Universidad Nacional Autónoma de México. The El

Doctor platform was chosen for a variety of attributes. It is an exceptional outcrop with minimal previous study. It is also an excellent example of a Cretaceous isolated carbonate platform and has undergone moderate penetrative deformation similar to some of the platforms being currently explored in the far western Gulf of Mexico. Abdulah is using a state-of-the-art digital outcrop imaging capabilities along with conventional field mapping, measured section collection, and facies analysis to construct a stratigraphic framework for the platform. The El Doctor platform has a full spectrum of platform interior, platform margin, slope, and basin elements characteristic of the trend of Cretaceous isolated platforms of the western GOM. This research represents the first study of this scale conducted on the Cretaceous of Mexico in recent decades.

Documentation of Lower Cretaceous (Albian) large-scale microbial mounds and associated rudist mounds on the Comanche Shelf

Outcrop exposures in the northern Maverick Basin along the Devil's River Trend expose a series of large (up to 3 m) microbial mounds showing concentric growth structures. These are the only known Lower Cretaceous Albian microbial mounds in Texas. This unique exposure enables an excellent opportunity to document microbial mounds for depositional setting, depositional process, and pore networks within the Albian and provides a comparison to similar facies which become reservoirs in south Atlantic basins in offshore Brazil and West Africa. This interesting section has moderate-energy microbial sediments deposited above mounds. Following a time break, large rudist caprinid mounds developed. The distribution of facies and pore types will be characterized to enable comparison to other microbial mound features and will placed into the appropriate Albian high-frequency cycle to better understand the paleogeography of this unique facies on the Lower Cretaceous platform. We will also characterize the diagenesis and pore networks of the microbial lithofacies. This work was just published Sedimentary Geology (2018, v. 371, p. 75-88). We are now expanding are area of investigation (from Sonora to Rocksprings) to include other high-energy units of this rimmed intrashelf basin.

Upper Jurassic carbonates: Regional controls and detailed subregional ooids reservoir distributions in the Campeche Bay area

The Kimmeridgian Play is the second most productive unit in the southeast Gulf of Mexico. The productive facies correspond to ooids packstone-grainstone, partially or totally dolomitized interpreted as being deposited as oolitic banks in a high hydrodynamic energy depositional setting. The Late Jurassic time is a transition time between transpressional and extensional tectonic and potentially early Callovian salt movement. The deposition of the high energy carbonates during the Late Jurassic has been shown to be controlled by antecedent topography created by the tectonic regime. Because carbonates such as ooid are deposited in a very restricted shallow water interval, they are preferentially developed on sea-floor topographic highs. Because of the combination of relative sea level changes and continuous tectonic activity and salt movement during the Late Jurassic, the distribution of the Late Jurassic carbanates is likely complex and requires a regional integration of tectonic and stratigraphy to better understand the controls on their distribution at the regional scale and at the sub-regional scale.

In addition, the distribution of reservoir quality is further complicated by post-depositional diagenetic transformation. This study aims at: (1) Regional characterization of syn-tectonic shallow water Oxfordian and Kimmeridigan shallow water carbonate deposits in several geological province, (2) improve our understanding of antecedant topography control on Upper Jurassic carbonate reservoir by integrating tectonic restoration and carbonate stratigraphy, (3) identify the geological factors that controlled the distribution of oolitic banks in the Kimmeridgian Play in shallow waters Campeche Bay area.

Cenozoic carbonate platforms systems, high-resolution stratigraphy, and platform-to-basin stratigraphy in passive and tectonic settings

RCRL research addresses a large variety of scales in order to understand the influence of tectonics on platform-to-basin stratigraphy and margin styles. With this in mind, significant effort in Cenozoic systems will help to improve key controls that tectonics and sediment influx can have on carbonate reservoir and petroleum system characterization. In 2019 focus will be on three main topics: (1) the complexity of icehouse climate on high-frequency cycle architecture, sedimentation rates, diagenesis, and resulting reservoir heterogeneities as expressed in Pleistocene systems of the Caribbean, (2) the variation of platform architecture under the influence of large-scale compressional tectonics, subsidence rates and siliciclastic influx (NW Shelf of Australia and Turkey), and (3) Shelf-to-Basin analysis of Tertiary mixed-carbonate siliciclastic depositional systems of the Northwest Shelf of Australia.

Pleistocene Carbonate Stratigraphy – Lessons for Better Understanding of Ancient Carbonate Flow Units, Platform Architecture, and Diagenetic Patterns

The last 5 years has seen the RCRL group grow from a passive field trip group in the area of Pleistocene carbonate platform evolution to one that is actively engaged, cutting new research directions, and establishing multiple cooperative projects with the industry (ExxonMobil) as well as academic groups both within UT and externally. There is substantial fertile ground for improving our understanding of the complexity and heterogeneity of carbonate cycles at the 100 ka scale and finer, with resolution of eustatic amplitude and chronology that cannot be yet reproduced in older Cenozoic or other Phanerozoic examples. An improved understanding of the limitations of mapping carbonate cycles to sea-level fluctuations and linking these to external drivers such as Milankovitch forcing functions is now available. The eccentricity/ obliquity/ precession tuning of carbonate cycles appears to be a major stretch even considering a time frame as short as 400 ky. Understanding the limitations of our conceptual knowledge in this way must improve our understanding of ancient reservoir systems.

Variations in carbonate factories, dominant grain types, and thereby styles and magnitudes of early diagenesis/cementation are now seen to fluctuate at the 100 ka scale. This realization,

and the resultant differences in rock-mechanical properties and porosity and permeability evolution are currently mostly unappreciated when considering changes in diagenetic patterns at the cycle or high-frequency sequence scale.

We plan to leverage the framework we have established on the islands of West Caicos, Providenciales, Little Cayman, and San Salvador, to develop a new conceptual framework for modeling stratigraphic and diagenetic patterns in icehouse carbonates. Work will focus this coming year on better understanding of one of the short-lived interglacials within marine isotope stage 5, the last interglacial, or LIG. This substage, MIS 5a, is the last significant warm period before onset of the Sangoman glacial period. It is thought to have recorded a sea-level maximum at about -8 m relative to present day SL and is characterized by a distinctly different, skeletal, non-oolitic shallow-water factory. This difference, coupled with what appears to be a distinctly more humid paleoclimate, will form an excellent comparison against the warm peak interglacial of MIS 5e.

Regional mapping on San Salvador and other Bahamian/BWI islands will be carried out. We will use of relative age dating, and where possible U-Th techniques, as well as detailed petrography to characterize grain types and diagenetic patterns will be conducted during 2018-19.

Completion of the larger mapping project on the island of San Salvador will wrap up in 2019 and is planned to result in a substantially revised stratigraphic framework of the island as well as an improved model of Pleistocene stratigraphy of the region.

Miocene Carbonate Platform in the Mut and Adana Basins, south Turkey

Recent exploration activity in the Eastern Mediterranean, southern Permian Basin and the Cuban foreland highlights the need to improve understanding of carbonate systems that develop in back-arc and foreland basins. Ongoing efforts by RCRL includes investigating Miocene carbonate platforms in south-central Turkey that developed in various tectonic settings and have contrasting platform style, size, and geometry. Two basins have been the focus of much of the work to date. The Mut Basin is a more slowly subsiding intramountain basin compared to the Adana Basin. The overall slower subsidence rate favors the growth of a thick 10 to 45 km wide attached Miocene platform with episodes of strong basinward progradation and a nearly complete infill of the deep intramountain basin. In contrast, the high subsidence rate in the Adana Basin resulted in a narrow (1-5 km) attached back-stepping platform that developed over highly irregular topography that created a large shelf-to-basin relief. In addition, in the Adana Basin there is a significant contemporaneous clastic infill of the basin. The main emphasis of this research is to develop a detailed comparison between the stratigraphic architecture of two icehouse carbonate systems forming along different subsidence gradients. In 2019 we will construct a set of representative regional cross-sections from both basins and collect rock samples for biostratigraphy and strontium isotope analysis to improve the resolution of the existing chronostratigraphic framework. Excellent exposure of

these Miocene platforms provide a range of high-quality analogs for time-equivalent plays and prospect in the Eastern Mediterranean area and in areas of variable post-tectonic subsidence.

Shelf-to-Basin Analysis of Tertiary Mixed-Carbonate Siliciclastic Depositional Systems of Northwest Shelf, Australia

There is a critical need for insight of waning tectonic systems and the role of subsidence in carbonate platform heterogeneity. This need combined with available high-resolution 3D seismic data provides a unique opportunity for a multi-year, interdisciplinary study to investigate the stratigraphic architecture and evolution of the Tertiary mixed siliciclastic-carbonate system of the Northwest Shelf of Australia. Our long-term goals are to assess large-scale controls on the distribution and architecture of the main depocenters on the shelf and in the basin for the entire Tertiary interval. Paleozoic structure, subsidence history, hinterland uplift, and export of siliciclastics are all primary controls when the system is investigated at the 100-1000's km scale.

Based on our results from the previous years, the Pre-Mesozoic structure as well as the early Tertiary accumulation of mixed siliciclastic and carbonates seems to have the most significant impact on both the platform and slope architectures of the pure carbonate Lower Miocene interval. In previous years, we have created stratigraphic cross-sections and geomorphologic maps at the regional scale that highlight the degree of variability for more than 1000 km along that continental margin. In 2019, our primary objectives are to continue mapping sediment pathways from inner shelf-to-basin, identify and map successive depot-centers along the profile and assess the tectono-sedimentary influence of the Pre-Miocene on the morphology of Lower Miocene carbonate shelf-to-basin profile as well as the distribution of potential reservoir intervals. In 2019, we will also, extend our analysis of the deep-water deposits in the ODP cores, including pore network analysis, Sr dating, and geochemistry analysis. In addition, we will start building a database of morphometric data of various seismic geobodies, initially focusing on the slope architectural elements (channels-levees, MTCs, canyons, etc.). The results of this research will benefit explorationists that investigate carbonate systems at the regional scale along continental shelves and will provide a reference analog on regional factors that control the variability on carbonate platform developments.

Modeling carbonate systems

Upper Cretaceous Reservoir Characterization of a Middle Eastern field

In collaboration with a visiting scientist from ZhenHua Oil, we will apply RCRL workflows to this upper Cretaceous reservoir (e.g., Mauddud Fm., Rumaila Fm., Mishrif Fm., and Khasib Fm.). Broad objectives are to integrate mechanical and acoustic properties into an integrated mechanical stratigraphy reservoir characterization workflow using 3D seismic, core and well log data.

Regional scale 3D models of the Delaware Basin, Central Basin Platform, and Midland Basin

The long-term goal of this project aims to combine numerous stratigraphic and structural interpretations created over RCRL's 30 year history into a single, multi-scale 3D model to serve as an integration platform for the regional Permian Basin analysis. Various publicly available datasets from the BEG, University of Texas department of Geology - as well as additional public maps and cross-sections, will be georeferenced within this 3D model. The main focus of this super basin model is to create a detailed, central database of depositional, stratigraphic, structural, lithological, petrophysical, and engineering properties of the Permian Basin Paleozoic carbonate depositional and reservoir systems.

Integrated structural and stratigraphic 3D outcrop model of the Grayburg-San Andres interval, Brokeoff Mountains, TX and NM

The Brokeoff Mountains are a highly contain a well exposed analog of the Grayburg reservoir onlap similar to the geometry contained within the Fasken Ranch 3D in the Midland Basin.

With the growing interest in water-disposal in the Permian Basin, detailed work on the fault-related fracture zones exposed in the Brokeoffs will be mapped to determine the style, scale, and intensity of the fractures that develop within the Yeso, San Andres, and Grayburg units.

Fundamental Overarching Research Projects within RCRL

Within the RCRL research group we have several broad themes that we address with specific studies in order to better understand the bigger picture of carbonate systems. Each year we present updates on these efforts during the Annual Sponsors Meeting. These overarching topics include: (1) development of reservoir properties database; (2) study of tight limestones and dolomite reservoirs; (3) carbonate rock mechanics and acoustic properties; and (5) fractures associated with carbonate fault zones. By having a longer view on these overarching research topics, we are more confident about the impact that individual studies have on broad carbonate system research and we use these reviews to identify gaps in knowledge that RCRL researchers can address. Details of each of these overarching efforts are highlighted below.

Origin and Petrophysics of Tight Limestone and Dolomite Reservoirs

Gas production from "tight" carbonate reservoirs is a significant unconventional resource, with important limestone examples including the Lower Cretaceous Stuart City Trend and Sligo Trend in south Texas, many of the Middle East Lower Cretaceous reservoirs, and Paleozoic dolostone examples including the Clear Fork in the Goldsmith Field, Central Basin Platform and the Lower Ordovician Ellenburger of the Fort Worth Basin. We are searching for other oil and gas fields that produce from low-permeability limestones to determine how micropores contribute to production. We have collected case histories that span stratigraphic ages and continue to document case histories from the Paleozoic, especially dolostone reservoirs. An important part of this study is investigating and cataloging of micropore carbonate reservoirs worldwide. In this project, we have defined the types, origins, temporal and spatial distributions, and petrophysical properties of microporous carbonates. We have recently extended our research into dolomites. We have made strong progress in defining the origin of different micropores, and now we need to document enough case histories in order to summarize their petrophysical characteristics and how to predict the regional distribution of micropores in limestones and dolomites.

Carbonate Rock Mechanics and Acoustic Properties Research

This long term project investigates the change in petrophysical and mechanical properties associated with diagenetically-modified pore types within known primary textures and/or lithofacies. This characterization effort will be followed by an assessment of the best rock physics model to reproduce the experimental measurements. The ultimate goal is to calibrate and evaluate the ability of various rock physics models to predict the wireline log response and seismic response associated with changes in pore types in carbonate rocks. In 2017, we will select carbonate cores that exhibit a simple pore type change within a single lithofacies, preferably within the same interval. This project relies on collecting a wide range of nondestructive data on the core and calibrate those measurements with strategically selected MicroCT scan, petrophysical, acoustic and mechanical measurement as well as detailed petrography on 1-in core plugs. Based on those data, we will characterize and quantify

geometrical parameter of the pore network in 2D (thin section) and 3D (CT scan) through image analysis, calculate mechanic moduli from acoustic properties and stress-strain curves, and integrate and compare laboratory measurements with wireline logs. Finally, we will then be able to critically evaluate which rock-physics model performs the best based on core measurement (for instance compare DEM extended Xu-White model and Extended Biot Theory model) and perform rock-physics based transforms of wireline-log suites to predict acoustic signature at the wireline-log and seismic scale.

INFORMATION TRANSFER

Our industrial sponsors receive research results at annual review meetings, in short courses, during mentoring activities, in publications, and on our continually updated, members-only RCRL website database (http://www.beg.utexas.edu/rcrl/ members/). This online searchable website allows us to protect your investment in our collective research and makes previously presented material easy to locate and download from anywhere in the world. Each paying member company is given login information to the 'members only' portion of our website.

The website contains digital presentations, including archived video and annotated presentations, core workshop guidebooks, and field-trip guidebooks from past and current RCRL field trips. Supplemental data such as maps, core photos, porosity and permeability data, digital-outcrop reservoir models are available upon demand or in online database under development.

In the last two years we have added two new databases:

(1) Carbonate Reservoir-Quality Database that has over 20,000 core-plug porosity and permeability data points; and
(2) ArcGIS-based database of regional Austin Chalk data including core and thin-section descriptions and photographs, SEM microimages (rock texture, fabric, mineralogy, and pore networks), porosity and permeability data, XRF data, XRD Data, RockEval and Hawk TOC data, etc.

New databases that are being added in 2019 include:

(3) Searchable Catalog of RCRL Presentations and Extended Abstracts (coming in 2019)
(4) Digital Outcrop Catalog to Arc-GIS (coming in 2019)
(5) RCRL Core Workshop Database to Arc-GIS (coming in 2019)

Workshops and Field Seminar

In addition to the Annual Review Meeting with the associated annual field trip and core workshop, we will be offering a training workshop in spring 2019 in Austin. The workshops are interactive and utilize subsurface data, including seismic, wireline logs and core, along with

applicable outcrop analogs to emphasize applications of key elements that have been developed by RCRL over the past three decades.

In the spring of 2018 we conducted a week-long series of one-day, standalone courses that included (1) introduction to carbonates and principles of carbonate exploration and exploitation, (2) seismic characterization of carbonate systems, (3) integrated core, log, and seismic analysis for construction of high-resolution sequence frameworks for reservoir characterization and modeling, (4) Buda and Austin Chalk fractured reservoir core workshop, and (5) 3D fracture modeling using carbonate rock properties and mechanical stratigraphy. We intend to run the workshop or short course in May, 2019. Topics for the workshop or short course will be determined by the interests of the sponsor companies, which will be solicited before the end of 2018. Member companies are encouraged to send staff or teams for one, several, or all of the modules covered in the short course as there is no enrollment fee.

Sponsor Interactions with RCRL Staff

RCRL makes a concerted effort to interact with sponsors during the year through company-specific discussions and short-term projects to help transfer research results into their exploration and production workflow. Over the last several years, RCRL researchers have visited numerous U.S. domestic and international companies. In the past year we have traveled to company offices or hosted groups in Austin.

If your company has an interest in developing a cooperative project with members of the RCRL staff, we would like to hear from you. These cooperative projects, in which RCRL and company staff learn together through hands-on data analysis of current production/exploration challenges, are essential to maintenance of the real-world relevance of our group. In addition, access to data that can be worked on, as well as presented, is imperative.

RCRL Graduate Student Mentoring and Thesis Supervision

RCRL has produced a significant number of graduates with advanced degrees in carbonates that are now working in industry. Charles Kerans, a professor and the Chairman of the Department of Geological Sciences, Jackson School of Geosciences, holds the Robert K. Goldhammer Chair in Carbonate Geology. He teaches both undergraduate and graduate carbonate courses and this gives RCRL a unique ability to have students interacting with RCRL scientists and researchers while they obtain their degree. Xavier Janson, Jerry Lucia, Chris Zahm, Steve Ruppel, and Bob Loucks all teach or have taught courses in the Jackson School, and several are on the Graduate Studies Committee. These researchers have or are presently supervising MS and PhD students. Students obtain comprehensive training in carbonate systems working on RCRL projects and interacting with RCRL professional staff. Each student presents his or her work at the Annual Review Meeting, which is an opportunity for sponsors to get to know students and consider them for possible future employment. A list of recent and active students is located on our website.