Petroleum Engineering Department Facilities

Departmental Facilities and Individual Faculty Research Laboratories:

**Acid Fracture Research Laboratory**
Dr. Dan Hill  
Dr. Ding Zhu
The Acid Fracture Research Lab is designed to study acid fracture conductivity behavior as functions of important parameters. Each experiment has 4 major steps; rock sample preparation, cell preparation and loading, acid injection, and fracture conductivity measurement. The set-up consists of an acid injection apparatus, a fracture conductivity measurement apparatus, and a profilometer for surface scanning.

The acid injection uses a modified API conductivity cell that holds the samples in place during the experiments. The cell is corrosion resistant and can withstand pressures that over 10,000 psi. This injection system is designed to flow acid through the API cell at high pressures (greater than 1000 psi). The pressure transducers display the pressure inside the cell, across the fracture, and the leak-off pressure (across the samples). The Chem-Pump is a metered pump that is able to flow up to a rate of 1.05 liters/minutes. Thermocouples located upstream and downstream of the cell provide temperature data during the injection. Backpressure regulators ensure that the system stays at the desired pressure of 1000 psi.

The apparatus used to measure fracture conductivity is designed to flow a fluid through the API cell that is subject to varying closure stresses. A load frame holds the cell in a horizontal position. Pressure transducers measure the pressure across the fracture and in the cell. Three pressure transducers measure different ranges of pressure drop. A thermocouple located downstream of the cell provides temperature data. The flow rate of the fluid flowing through the cell is measured using a stopwatch and a graduated cylinder.

The surface of the rock samples can be scanned with a profilometer before and after acid injection to determine the volume of rock removed during the acid injection. The apparatus includes a laser sensor, control box, and PC software interface. The profilometer uses the laser displacement sensor to record the vertical height of the sample as it travels over the entire length and width of the sample.

**Acid Stimulation Laboratory**
Contact: Dr. Dan Hill  
Contact: Dr. Ding Zhu
In this laboratory, we develop new and better methods to measure acid-fracture conductivity so industry can better design well completions in deep, carbonate reservoirs.

**Advanced Instruments Lab**
Contact: Dr. Hisham Nasr-El-Din
The Advanced Instruments Lab contains equipment used in the detection, classification, analysis, and imaging of rock samples, sediments, and fluids. Descriptions of each piece of equipment are listed below:

- **Optima 7000 DV Inductively Coupled Plasma (ICP)** - A type of mass spectrometry which is capable of detecting metals and several non-metals at concentrations as low as one part in 1012 (part per trillion).
- **S2 Ranger X-Ray Fluorescence (XRF)** - An x-ray instrument used for routine, relatively non-destructive chemical analyses of rocks, minerals, sediments and fluids.
- **Evex Mini- Scanning Electron Microscope (SEM)** - A type of electron microscope that produces images of a sample by scanning it with a focused beam of electrons.
- **XDS 2000 X-Ray Diffraction (XRD)** - Used for determining the atomic and molecular structure of a crystal, in which the crystalline atoms cause a beam of X-rays to diffract into many specific directions.
- **MSC-1000 Mini-Sputter Coater** - Used to coat the gold to the samples for SEM.

**Anadarko Petrophysics Laboratory**
Contact: Dr. Sara Abedi
This lab focuses on the petrophysical techniques listed below.

- **Distillation** - Either of two extraction methods (Dean-Stark) or Retort Distillation can be used to determine the fluid saturation inside the cores.
- **Coreflood setup** - Used to determine the initial permeability of the core samples using one fluid. It can also be used to determine the relative permeability to oil and water when both fluids are injected simultaneously.
- **Centrifuge** - Used to determine the capillary pressure data for a core.
- **Profile Perameter**
- **Sonic sifters** - Used to determine the particle size distribution and sieve analysis.
- **Oil bath** - Used to determine the viscosity of liquids at higher temperatures.
- **Acoustic velocity** - Used to determine the wave velocities on rock samples as a function of confining stress and pore pressure comprising an ultrasonic transducer assembly, pressure vessel (Core Holder) and pore pressure intensifier. The pore pressure intensifier part is not currently available in the unit in lab 212. Rock properties such as shear modulus, Poisson’s ratio, bulk modulus, and Young’s modulus can be calculated from the wave velocities.
- **Helium porosimeter** - Used to determine the porosity for core samples using simple Boyle’s law.
- **Tensiometer** - Used to determine the surface and interfacial tension for liquids using Wilhelmy plate method.

**BP Laboratory for Field Studies**
Contact: Dr. Maria Barrufet
This laboratory provides a state-of-the-art technology and computer resource for advanced, team-based reservoir engineering courses. The lab will provide students for the first time with GeoGraphix software, reservoir simulation software by Computer Modelling Group Ltd. (CMG), 40 new computer workstations, and three SMART boards.
Chaparral Fischer CO2 EOR Laboratory
Contact: Dr. David Schechter
Research projects in this lab include CO2 Enhanced Oil Recovery in Unconventional Liquid Reservoirs and CO2 Injection in the North Burbank Unit. More information on this research can be found on the Model and Improved Oil Recovery from Fractured Reservoirs website.

A joint venture with Chaparral Energy and generously sponsored by Mr. Mark Fischer (CEO of Chaparral Energy), the Chaparral Fischer CO2 EOR lab in conjunction with Naturally Fractured Reservoir lab studies salient features of gas injection using CO2 and other modified natural gases for improving oil recovery from naturally fractured conventional and unconventional reservoirs. Studies also focus on improving foam stability using nanoparticles and surfactants for better mobility control and higher sweep efficiency of gas injection as well as characterizing gravity segregation in naturally fractured reservoirs. The lab boasts of state of the art equipment for minimum miscibility pressure measurements and gas injection besides standard equipment for density and rheological property measurements.

Chevron Drilling and Completions Laboratory
Contact: Dr. Jerome Schubert
This teaching lab has a drilling cementing and stimulation measurement equipment as well as a drilling rig simulator and software. The lab simulates a realistic rig floor using a drilling simulator and they hydraulic tubing tongs currently used for research and other equipment typically found on a rig floor. The hands-on approach will help student learn the importance of drilling mud properties and how changes can help identify and solve potential drilling programs.

Chevron Petrophysical Imaging Laboratory
Contact: Dr. David Schechter
The Chevron Petrophysical Imaging Laboratory has a state of the art Toshiba Aquilion RXL CT Scanner with 3D advanced visualization software. Its 16-detector row 32 slice computerized tomography system delivers high speed iterative image reconstruction of 0.5 mm data sets at up to 16 images per second. The scanner has a 72 cm gantry opening with +/- 30 degrees tilt with an accurate 0.5 mm x 16-row high-resolution detector. Also, the CT Scanner has an industry leading low contrast resolution of 2mm @ 0.3%.

The Toshiba Aquilion RXL CT Scanner is a high-precision instrument that can measure the porosity, fluid density and changes in saturation in cores samples and enhanced oil recovery flood experiments such as water, gas or CO2 flooding. Also, it can be used to visualize natural fractures in cores samples and wormhole propagation in cores exposed to acid treatments.

More information on the research performed in this lab can be found on the Modeling and Improved Oil Recovery from Fractured Reservoirs website.

Corrosion and Foam Stability Lab
Researchers in the Corrosion and Foam Stability Lab in the Harold Vance Department of Petroleum Engineering at Texas A&M University study the corrosive effects of chemicals and other substances on developed formations and drilling equipment, and seeks ways to mitigate and prevent it. This laboratory also houses equipment for the study of foam stability to develop foams that can be used as drilling and fracturing fluids, as well as deliver proppants, corrosion inhibitors, and other useful liquids and particles to the substrate.

**Dual Gradient Drilling Lab**
Contact: Dr. Jerome Schubert
The Dual Gradient Drilling Lab is designed to help the industry better understand what will happen in the junction between the marine drilling riser and the subsea pump. The equipment is currently set up to model a deepwater dual gradient riser/subsea pump/return line system utilized in ultra-deepwater drilling. We hope to determine how much gas entering the riser is diverted to the subsea pump and how much continues upward and accumulates at the top of the riser, and how we can maximize the gas that exits through the subsea pump.

Part of this study will develop procedures where the riser itself can be utilized in handling this gas from kicks. This type of research will help future drilling operations recognize and avoid the dangerous pressure situations that led to the Macondo blowout, and possibly create safer equipment to further reduce risk.

The lab system consists of clear PVC pipe (six inches in diameter) to simulate the marine drilling riser, small diameter clear PVC inner pipe to simulate the drillstring and a six-inch outlet approximately six feet from the bottom of the “marine riser” to act as the outlet of the riser (inlet of the subsea pump). There are two centrifugal pumps: one to act as the mud pump where they can pump straight up from the bottom of the riser or down the drillpipe and up the riser annulus, and one connected to the riser outlet to act as the subsea pump (either for the enhanced drilling EC Drill pump or the SMD Mudlift pump). Finally there is an air compressor used to pump air into the bottom of the riser to simulate gas entering the system. The clear pipe is mounted to a steel frame which can be lifted from horizontal to vertical by a winch attached to a beam in the building. The lab can run experiments at any angle from horizontal to vertical.

**Crisman Institute**
Director: Dan Hill
The Crisman Institute is essentially a liaison among researchers and the industry centralizing departmental efforts to develop proposals and explore new avenues to fund projects. The Institute encompasses the existing centers, laboratories and research projects within the department but does not exert control over any of them. Instead, it provides opportunities for researchers to coordinate and collaborate, while still conducting their research independently. The Crisman Institute has funded over 30 projects in the following 4 thrust areas: Geology and Geophysical Characterization; Nano and Molecular Scale Research; hydraulic Fracturing; and Reservoir Modeling.
**Visit the Crisman Institute Website**
Evaluation of Oilfield Chemicals Laboratory
Contact: Dr. Hisham Nasr-El-Din
Extensive testing is performed on oilfield chemicals before and after being selected for use in production operations. Some tests include zeta potential to test clay stabilizers or general surface charges and HPLC to determine the molecular weight distribution of polymers.

Atomic absorption spectroscopy (AAS) is a spectro-analytical procedure for the quantitative determination of chemical elements employing the absorption of optical radiation (light) by free atoms in the gaseous state. In analytical chemistry the technique is used for determining the concentration of a particular element (the analyte) in a sample to be analyzed.

Gas chromatography (GC), is a common type of chromatography used in analytical chemistry for separating and analyzing compounds that can be vaporized without decomposition. Typical uses of GC include testing the purity of a particular substance, or separating the different components of a mixture (the relative amounts of such components can also be determined). In some situations, GC may help in identifying a compound. In preparative chromatography, GC can be used to prepare pure compounds from a mixture.

High-performance liquid chromatography (formerly referred to as high-pressure liquid chromatography), HPLC, is a chromatographic technique used to separate the components in a mixture, to identify each component, and to quantify each component. It relies on pumps to pass a pressurized liquid and a sample mixture through a column filled with a sorbent, leading to the separation of the sample components.

Zeta potential is a scientific term for electro kinetic potential in colloidal systems. The significance of zeta potential is that its value can be related to the stability of colloidal dispersions (e.g., multivitamin syrup). The zeta potential indicates the degree of repulsion between adjacent, similarly charged particles (the vitamins) in dispersion. For molecules and particles that are small enough, a high zeta potential will confer stability, i.e., the solution or dispersion will resist aggregation. When the potential is low, attraction exceeds repulsion and the dispersion will break and flocculate. So, colloids with high zeta potential (negative or positive) are electrically stabilized while colloids with low zeta potentials tend to coagulate.

Formation Damage Studies Lab
Contact: Dr. Hisham Nasr-El-Din
The Formation Damage Studies Lab studies the rheology properties of drilling fluids, the formation damage caused by drilling fluids, and the observations of fluid samples under heat and pressure.

- OFITE HP/HT Filter Press - It is designed for testing drilling fluids and cement under elevated temperatures and pressures. The unit simulates various downhole conditions and provides a reliable method for determining the effectiveness of the material being tested.
- HP/HT Visual Reactor - It is used for visual observations of reactions and other purposes.
- **Grace Instrument M3600 Viscometer** - It is engineered to do laboratory researches for advanced rheology testing. It is need to be used with a Microsoft Windows PC and the included M3600DAQ™ and M3600Frac™ software.
- **OFITE Five-Spindle, Single-Speed Multi-Mixer** - It is used in general purpose mixing of drilling fluids in preparation for laboratory tests of mud materials.
- **Laboratory Oven**

**Gas Hydrates Laboratory**
Contact: Dr. Yucel Akkutlu
Sophisticated high-pressure and low-temperature equipment is devoted to the understanding of the growth and dissolution of gas hydrate crystals in PVT cell and in porous media. Gas hydrates and fluids modeling under various subsurface conditions using thermodynamic equilibrium and non-equilibrium molecular simulations.

**Geomaterials for Energy Use and Environmental Sustainability Laboratory**
Contact: Dr. Sara Abedi
This laboratory is used to investigate the physics and chemistry of various interactions of reservoir fluids, introduced fluids and reservoir rock. Equipment includes unconfined imbibition measurement apparatus, unconfined rock strength measurement equipment, core flood apparatus, emulsion evaluation protocol and pH measurement equipment.

**Global Petroleum Research Institute (GPRI)**
Technical Director: David Burnett
The Global Petroleum Research Institute (GPRI) is the managing partner of a Cooperative effort to conduct critical research in the development of petroleum technology. Research findings will lead to the application of new and innovative technologies in petroleum exploration and production to address the increasing demand for cost-effective production and enhanced recovery.

The challenges facing the petroleum industry as result of the downsizing of corporate research are unprecedented. GPRI is the managing partner of a Cooperative effort to conduct critical research in the development of petroleum technology. Research findings will lead to the application of new and innovative technologies in petroleum exploration and production to address the increasing demand for cost-effective production and enhanced recovery. As leading producers of petroleum engineers and petroleum technology, The Texas A&M University System, through GPRI, is uniquely positioned to have a direct impact on the quality of education and research in an area of vital economic importance to the world.

The Global Petroleum Research Institute serves as the managing partner for collaborative research among 12 major, international oil producing companies. Governed by the Petroleum E&P Research Cooperative Agreement, hereinafter referred to as the COOPERATIVE, membership is open to any qualifying entity, with significant revenues from petroleum exploration and production activities, that elects to join in any research project. Projects are funded jointly, requiring participation of at least four Members of the Executive Committee to
authorize the initiation of research. There are no annual fees or Membership fees assessed. Cost is determined solely by the percentage of the total of any project(s) in which a Member chooses to participate. New members must agree to be bound by the terms and provisions of the COOPERATIVE. Service companies are not eligible for membership.

Cited by our Membership as "the new face of collaboration," GPRI conducts work addressing needs of the industry in a broad spectrum of areas. Since its first year of operation, GPRI has managed over $4M in research ranging from such immediate, critical issues as deepwater, multilateral technologies and completion technologies to longer-term interests in "next generation" answers to separation facilities, downhole logging tools and advanced completions technologies. An overhead charge, set annually by the Management Committee funds GPRI for the administration of the projects. For the 2000 Fiscal Year, the overhead rate is 10%.

Visit the GPRI Website

**Heavy Oil, Oil Shales, Oil Sands, and Carbonate Analysis and Recovery Methods (HOCAM)**

Director: Berna Hascakir

HOCAM is a research group focused on education and research for the recovery of unconventional oil resources with very low API gravity. The main objective of HOCAM is to find environmentally friendly and economic production solutions for challenging reservoirs including heavy oil, oil shale, oil sand, and carbonate host-rock environments. Our ultimate goal is to educate and train engineers on finding practical solutions for the recovery of these unconventional oil resources using thermal enhanced oil recovery (thermal-EOR) methods.

We bring new insights to the thermal-EOR methods with the application of unconventional technologies such as smart well technologies and seismic monitoring to track thermal fronts. This is expected to reduce environmental footprints and minimize the production cost of oil per barrel. Our solution strategies are empowered with the interdisciplinary vision of the research team.

As the success of any thermal-EOR method highly depends on the chemical, thermal, and other physical properties of the reservoir rock and fluids, we propose to extend one-dimensional experimental studies for dynamically tracking the thermal front behavior to the more natural three-dimensional environment. Furthermore, our ability to continuously measure the chemical and physical changes in oil, water, gas, and rock allows us to understand the degree of upgrading in oil. We are also developing solutions to manage water and gas produced in the process. All this is complemented with our development of simulation plug-ins compatible with existing commercial reservoir simulators that will allow overcoming uncertainties regarding oil-field properties or the thermal recovery process itself.

Visit the HOCAM Website

**High Pressure/High Temperature Drilling Laboratory**

Contact: Dr. Jerome Schubert
The backbone of the high pressure/high temperature (HP/HT) laboratory is our Chandler 7600 HPHT mud viscometer. With this we measure the rheological properties of drilling fluids (and other fluids as well) to 600°F and 40,000 psia. We also utilize the pressure and temperature elements of the viscometer to charge our HP/HT cement fatigue failure cells where we can simulate the stresses imposed on the cement sheath during multistage hydraulic fracturing treatments. In addition we have the capability to measure gas viscosities with extended ranges of temperatures, pressures, gas specific gravities, and quantities of non-hydrocarbons. These data can be used to extend the range of applicability of the correlation to 400°F and at least 25,000 psia.

We are currently constructing an extreme HP/HT PVT cell where we will have the ability to measure the PVT properties of HPHT Drilling Fluids, reservoir gasses, and the solubility of reservoir gasses in drilling fluids to conditions equivalent to the Chandler 7600 Viscometer. The goal is then to inject the gas laden drilling fluid into our Chandler 7600 viscometer to determine the effect of the gas on the rheological properties of drilling fluids. This will allow us to develop an extreme HPHT gas kick behavior simulator.

**Hydraulic Fracture Conductivity Laboratory**

Contact: Dr. Dan Hill
Contact: Dr. Ding Zhu

The Hydraulic Fracture Conductivity Lab was established to simulate the hydraulic fracturing fluid pumping, fracture closure, and to measure the fracture conductivity over closure stresses.

It mainly consists of 1) the fluid injection module; 2) the closure stress application unit; 3) the conductivity cell assembly; and 4) the data acquisition system. The fluid injection module can flow single phase gas, liquid, as well as proppant loaded cross-linked gel at flow rates equivalent to field applications. The hydraulic load frame can apply fracture closure stress up to 15,000 psi on rock samples with dimensions recommended by ISO 13503-5 at stress application rate of 100 psi/minute. The modified API conductivity cell can accommodate samples up to 6 inches thick in total, which makes it reasonable to account for fluid leakoff during the experiment. The data recorded in the experiment include differential pressure across the sample, sample mid-point pressure, fluid flow rate, closure stress, axial displacement of the stress loading piston, et al.

**Killough Research Group**

Director: John Killough

In our research group, we investigate different aspects of reservoir simulation in various scales, from advanced high performance computing methods in gigantic reservoirs, to challenging micro scale storage and flow mechanisms in ultra-low permeability shale and fractured carbonate reservoirs.

Visit the Killough Group Website

**Matrix Acidizing Laboratory**

Contact: Dr. Dan Hill
Contact: Dr. Ding Zhu
The matrix acidizing lab is used to simulate the acidizing process. Equipment mainly consists of the syringe pump; the brine/acid accumulator; the core holder; the data acquisition system; and the back pressure regulator. During the experiment, the syringe pump pushes the brine/acid out of the accumulators to the core. The pressure behavior is monitored by the data acquisition system.

The syringe pump is used to pump the fluids during experiment, either in constant flow rate mode or constant pressure mode. With two cylinders, it can continuously deliver flow rate, over a range of 0.1 ml/minute to 400 ml/minute, at a pressures range of from atmospheric to 7,500 psi. The accumulators are used to store brine/acid in the system. A Teflon piston is set inside the accumulator, which separates the accumulator into two chambers with one side filled with hydraulic oil and the other side filled with brine/acid. The core holder has three sizes: a 1-in diameter by 6-in length, a 1.5-in diameter by 20-in length, and a 4-in diameter by 20-in length. They have excellent corrosion resistance and capable to withstand a working pressure of 3,000 psi and temperatures of 300°F. The data acquisition system includes a pressure transducer, a NI signal processing board, and a computer installed with Labview software. It writes the pressure drop into a local file every 0.5 second. The back pressure regulator is used to create a pre-set fluid pressure before the experiment. It can support 6,000 psi pressure at maximum. This setup has been utilized to study the wormholing efficiency under different conditions. With high range back pressure regulator, the carbon dioxide behavior during acidizing can also be studied.

Model Calibration and Efficient Reservoir Imaging (MCERI)
Directors: Akhil Datta-Gupta and Michael King
The MCERI (Model Calibration and Efficient Reservoir Imaging) industrial research consortium at Texas A&M University has been at the forefront of reservoir modeling, history matching, and streamline simulation technologies for well over the last decade. Much of the mathematical foundations behind modern streamline simulation have been developed in the research consortium, which is co-directed by Dr. Akhil Datta-Gupta and Dr. Michael J. King. Dr. Datta-Gupta and King co-authored the SPE textbook on the subject, ‘Streamline Simulation: Theory and Practice’. The research consortium continues to be one of the most active centers for the development of streamline technology and its applications to reservoir management and optimization, multi-scale data integration and history matching, upscaling/upgridding, and more recently, performance analysis and optimization of unconventional wells.

Reconciling high resolution geologic models to dynamic data such as transient pressure, tracer and multiphase production history or time-lapse seismic data is by far the most time-consuming aspect of the workflow for both geoscientists and engineers. The situation is further complicated by the rapid progress in well-construction technology and the advent of smart wells and permanent down-hole sensors. The amount of data collected is increasingly becoming overwhelming and there is an immediate need to improve our capabilities to utilize the data in a timely and efficient manner. Furthermore, as the use of time-lapse seismic becomes more common in the industry, there is also an increasing demand for quantitative and efficient use of these data for reservoir characterization in addition to reservoir monitoring. A focus of the MCERI research consortium has been the development of novel techniques and efficient workflows for reconciling high resolution geologic models to pressures, rates, fluid production
and time lapse seismic response. This includes geologically consistent regionalization and re-parameterization, identification of spatial distribution of reservoir properties, and uncertainty quantification.

How coarse is coarse and how fine is fine? This is an often asked question in reservoir simulation and modeling. We have developed novel adaptive upgridding algorithms to address this question through the design of simulation grids that optimally preserve the reservoir heterogeneity and geologic features. These techniques have been extensively applied to simulation layer design for both conventional and unconventional reservoirs.

A more recent focus of the MCERI consortium has been development of novel approaches for performance analysis and optimization of unconventional wells. Using high frequency asymptotic methods we have generalized the concept of depth of investigation to unconventional wells with multistage hydraulic fractures using a ‘diffusive time of flight (DTOF)’. The DTOF can be computed using fast marching methods for visualization of well drainage volumes in the presence of hydraulic and natural fractures. The fast marching methods can be orders of magnitude faster than conventional reservoir simulators and allow for efficient computation of pressure and rate transient response, matrix-fracture parameter estimation and optimization of well completion strategy. More importantly, in a manner analogous to streamline simulation, we can use the DTOF as a spatial coordinate to reduce the 3-D diffusivity equation into an equivalent 1-D equation leading to a comprehensive and fast flow simulator for unconventional oil and gas reservoirs with relevant micro and nano-scale physics including multiphase and compositional effects (patent pending, 2013).

A major emphasis of the MCERI research consortium has been field application and validation of the novel technologies in close collaboration with the industrial partners.

Software

• GRACE (Data correlation)

The GRACE program generates an optimal correlation between a dependent variable (say, y) and multiple independent variables (say, x1, x2, x3 .....x30). This is accomplished through non-parametric transformations of the dependent and independent variables. A common application is to correlate core permeability with well logs.

• E-FACIES (Electrofacies characterization)

E-FACIES partitions the well log data before building correlation and is based on Multivariate Analysis of Well Logs. Generally a suite of well logs can provide valuable but indirect information about mineralogy, texture, sedimentary structure, fluid content and hydraulic properties of a reservoir. The distinct log responses in the formation represent electrofacies that often can be correlated with actual lithofacies identified from cores, based on depositional and diagenetic characteristics.

• S3D(3D streamline simulator)
S3D is a 3-D streamline simulator for tracer flow and two-phase (oilwater or miscible flooding) displacement. The approach comprises of two steps: generating streamlines in 3D space and then solving the 1D equations analytically or numerically along the streamlines. The following are the important features of S3D.

1. Field-scale waterflood simulation
2. Pressure updating
3. Infill drilling / changing well configuration
4. Miscible flooding capability
   • S3D-INV (Streamline-based production data inversion)

S3D-INV is capable of performing two-phase production data inversion and interwell tracer test data inversion. For both of the cases, the estimable parameters are either absolute permeability or porosity. For the special case of tracer inversion, estimation of residual oil saturation is possible with the use of partitioning tracer test data.

S3D-INV is based on streamline-derived sensitivities and on iterative linearized minimization scheme. It can account for gravity and changing streamlines.

• ECLIPSE-INV / VIP-INV / FRONTSIM-INV
   These are special purpose software programs designed for history matching using commercial
   The source codes (C++ and FORTRAN) for the programs are available to MCERI members only.

Visit the MCERI Website

**Modeling and Improved Oil Recovery from Fractured Reservoirs (MIOR-FR)**
Director: David Schechter
Major focus areas of the group include experimental evaluation and modeling of improved oil recovery methods such as carbon dioxide injection and chemical treatments in conventional and unconventional liquid reservoirs. Studies within the group focus on characterizing pore scale rock/fluid interactions, measuring oil volumes from core flooding and imbibition studies and finally modeling lab results to field scale and provide insights on strategies for maximizing output from assets.

Our research group is equipped with the following laboratories that are stocked with world class equipment to conduct sponsored and independent research (*click the title for a list of equipment and capabilities*):

- Oilfield Chemistry Rock-Fluid Interaction Lab (RICH 802)
- Chaparral Fischer CO2 EOR Lab (RICH 803) | Naturally Fractured Reservoir Lab (RICH 614)
- Chevron Petrophysical Imaging Laboratory (RICH 823)

Visit the MIOR-FR Website
**Multiphase Flow Loop Tower Lab**

Contact: Dr. Peter Valko
Contact: Dr. Rashid Hasan

Known as the Tower Lab, the Petroleum Engineering Department at Texas A&M designed and built this 140-ft tall vertical flow loop to investigate various aspects of two-phase flow. The loop can use pipes of various sizes (1 to 6-in ID) to investigate flow through a single tube or through an annulus. The ability to capture high-speed video and pressure at various locations creates unique potential for a multi-media database for two phase upward flow.

Texas A&M is in the forefront of the new wave of research focused on understanding the dynamic interaction of wellbore and formation under loading conditions. The Tower Lab, has been rebuilt for this purpose. During a 3-year period, research within the Tower Lab has collected a considerable amount of experimental data. Dr. Valko and Dr. Hasan wish to address one of the identified weaknesses of current models: the lack of connection between critical rate correlations and wellbore hold-up correlations. They plan to make modifications to the Tower Lab main loop in order to observe hold-up both in the section above and below the entry point of the gas-liquid mixture. By direct comparison to hold-up results obtained with bottom entry, they will attempt to better understand the partial flow reversal phenomenon needed to fully understand liquid-loading. Their ultimate goal is to improve existing hold-up correlations and to quantify liquid accumulation rate in the well. They plan to use these results to develop a coupled dynamic model of the well/reservoir system. They have recently developed the concept of multiphase zero-flow pressure (MPZFP, P0) that would be utilized in their model to enable the determination of flow direction (well to formation or vice-versa) in the individual connections. Experimental results and new correlations are the main technical deliverables of this project.

**Nano Research Lab for Oil and Gas Applications**

Contact: Dr. Jenn-Tai Liang

The Nano Research Lab for Oil and Gas Applications at the Harold Vance Department of Petroleum Engineering is a newly established laboratory geared toward developing promising uses of nanotechnology for oilfield applications in both conventional and unconventional reservoirs.

**Naturally Fractured Reservoir Lab**

Contact: Dr. David Schechter

A joint venture with Chaparral Energy and generously sponsored by Mr. Mark Fischer (CEO of Chaparral Energy), the Chaparral Fischer CO2 EOR lab in conjunction with Naturally Fractured Reservoir lab studies salient features of gas injection using CO2 and other modified natural gases for improving oil recovery from naturally fractured conventional and unconventional reservoirs. Studies also focus on improving foam stability using nanoparticles and surfactants for better mobility control and higher sweep efficiency of gas injection as well as characterizing gravity segregation in naturally fractured reservoirs. The lab boasts of state of the art equipment for minimum miscibility pressure measurements and gas injection besides standard equipment for density and rheological property measurements.
Oilfield Chemistry Rock-Fluid Interaction Lab
Contact: Dr. David Schechter
The work in the Oilfield Chemistry Rock-Fluid Interaction Lab is focused towards characterizing interactions of injection/stimulation fluids such as brines and surfactants with reservoir rock and oil that directly affect well performance and oil recovery. The objective of such studies is to formulate affordable injection fluids that ensure high performance while favorably altering rock properties for secondary and tertiary modes of recovery.

Research Capabilities:
- Contact angle, IFT, and zeta potential measurements at reservoir temperature.
- Micro and nano-scale investigation of unconventional rock samples using CT scan technology and image processing techniques.
- Spontaneous imbibition and core flooding experiments in controlled conditions in conjunction with CT scan technology.

Research Activities:
- Investigating the effect of various surfactants on altering the wettability and interfacial tension of ULR core.
- Conducting zeta potential measurements to evaluate further wettability alteration and stability of surfactant solution films on the shale rock surface.
- Conducting spontaneous imbibition experiments with tested surfactants to measure oil expulsion volumes and hence, recovery as a function of time.
- Implementing forced imbibition using surfactant solutions to recover additional oil and test the penetration of various surfactants.

More information on the research performed in this lab can be found on the Modeling and Improved Oil Recovery from Fractured Reservoirs website.

Productivity Enhancement Lab
Contact: Dr. Hisham Nasr-El-Din
The Productivity Enhancement Lab addresses the key factors for well productivity improvement through a wide range of research studies, including optimized acid stimulation strategies and enhanced oil recovery flood experiments. Equipment listed below:
- Density Meter DMA 4100 M - Provides unparalleled ease of use and state-of-the-art digital density measurement.
- Spinning Drop Tensiometer - Developed for the measurement of interfacial tension, surface tension, absorption rate and particularly applicable to values of interfacial tension below 1 mN/m and especially below 10-2 mN/m, as may occur when employing surfactants for enhanced oil recovery.
- Bohlin CS (Constant Stress) - Advanced and accurate rheometer for measuring rheological properties on a wide variety of materials, for example cement paste or materials such as oils or admixtures.
- SP600 - A single-beam spectrophotometer. The instrument performs a self-test as soon as it is turned on, confirming proper operation and performance of all key components.
• Drop Shape Analysis Apparatus - Used for the evaluation of drop shapes and provides the user with a universally applicable tool for determination of physical properties such as the interfacial tension and the contact angle but also for observation of heat- and mass transfer phenomena at elevated pressures and temperatures.
• Coreflood System - A system that passes a fluid (gas or liquid) through a core sample at controlled pressure and temperature conditions and measures or monitors flow parameters. These systems are used for a wide variety of experimental research in the laboratory to develop, evaluate or prove concepts in the laboratory that will improve oil recovery and production in the field.

**Ramey Thermal Recovery Studies and Chemical Analysis Laboratory**

Contact: Dr. Berna Hascakir
Contact: Dr. Maria Barrufet

**Thermal Recovery Studies**

• In-situ combustion (ISC): One-dimensional combustion tube set-up consists of combustion tube assembly, pressure, temperature and flow monitoring system, and a gas analyzer. The experimental results obtained from combustion tube experiments are used to calculate the most important design parameters (air requirements, pump selection, well configuration, etc.) to field-scale implementation of ISC.
• Steam Flooding (SF): One-dimensional steam flooding experimental set-up consists of one-dimensional stainless steel tube, steam generator, pressure, temperature and flow monitoring system, and a gas chromatogram. The experimental results obtained from steam flooding experiments are used to calculate some important design parameters (SOR, Energy input, GHG emissions, etc.) for the field-scale application.
• Steam Assisted Gravity Drainage (SAGD): Two-dimensional SAGD consists of two stainless steel concentric cylinders, steam generator, pressure, temperature and flow monitoring system, and a gas chromatogram. The experimental results obtained from SAGD experiments are used to calculate some important design parameters (steam chamber development SOR, Energy input, GHG emissions, etc.) for the field-scale application.
• Electromagnetic and Electrical Heating: One-dimensional experimental set-ups consist of one-dimentional core holders, pressure, temperature and flow monitoring system, and a gas chromatogram.
• Three-dimensional experimental set-up for thermal recovery application: This set-up is designed to simulate the quarter of a reservoir for any thermal recovery application in a three-dimensional setting.

**Chemical Analysis**

• Saturates/Aromatics/Resins/Asphaltenes (SARA): The ASTMD2007-11 method is used to determine the SARA fractions of crude oil and bitumen samples.
• Thermal Gravimetric Analysis (TGA) and Differential Scanning Calorimetry (DSC): Reactivity of solid and liquid samples can be determined at different heating rates under different gas environments.
• Fourier Transform Infrared Spectroscopy (FTIR): Molecular structure of liquid and solid samples can be determined with the functional groups. The change in molecular structure in solid or liquid samples can be defined before and after any EOR application.
• Contact Angle and Interfacial Tension Measurements: Contact angle measuring systems provide a wide range of high-performance solutions for studying the surfaces of rock and hydrocarbons.
• Particle Size Analyzer and Microscope: Used to determine nanoparticle and colloidal particle sizes, emulsion type determination, and thin section analysis for rocks.
• Zeta Potential Measurement: Zeta Potential measures the potential difference between the surface charge of colloids and the suspending liquid. The electrostatic forces acting on the reservoir rocks and fluids are observed to determine wettability change, asphaltene precipitation mechanism, and emulsion formation mechanism.
• Rheometer and Density Meter: Dynamic viscosity and density of reservoir fluids are determined at different temperatures. Rheological behavior of the crude oils can be determined for the fluids having viscosity up to 4,000,000 cP.
• Total Dissolved Solid (TDS), pH, and Conductivity Props: The pH, TDS, and conductivity of produced water samples due to thermal recovery application can be monitored to observe the level of contamination in water.

Reaction of Acids with Reservoir Rocks
Contact: Dr. Hisham Nasr-El-Din
In this lab, the rotating disk apparatus is used to study reactions between fluids and solid surfaces. It is one of the important tools to collectively study the effects of mass transfer and chemical reactions by varying rotational speed and reaction temperature. The entire range of kinetics from mass transfer limited to chemical reaction rate limited can be investigated using this apparatus.

Rheology of Non-Newtonian Fluids
Contact: Dr. Hisham Nasr-El-Din
This lab focuses on the rheology of complex fluids. This lab is equipped with a rheometer, a coreflood setup, and an auto titrator.
• Auto titrator—Measurement of potential is to determine total acid number (TAN) with KOH in IPA as titrant and total base number (TBN) with HCl in IPA as titrant. Karl-fisher measurement is done with the Pt-electrode to determine the water composition of crude oil sample.
• Rheometer—Viscosity and dynamic rheological properties can be measured using this instrument. On the left side is the rheometer, and on the right side is nitrogen tank. High temperature and high pressure can be applied. The limit is 500°F and 1000 psi.
• Coreflood Setup—Coreflood test can be done with this setup at different temperatures. The core is 6-in long and 1.5-in in diameter. From left to right is hydraulic pump, three fluid accumulators, coreholder, pressure transducer, and hand pump. The transducer is connected to a computer and the data is recorded. It is also good for core up to 20-in long and is compatible for gas injection tests.

Rock Cutting Lab
Contact: Dr. Hisham Nasr-El-Din
The Rock Cutting lab is located within the Anadarko Petrophysics Lab (212) and contains a core drill - which can cut cores from 1/2 inch to 4 inch up to 20 inch length. It also contains two diamond tipped tile saws converted to cut cores and samples. The smaller one can cut to a depth of around 3.5 inch and handle pieces of rock 3.5x24x24. The larger one can cut 6x24x24. This equipment is used for cutting cores of different properties to supply to students for experiments.

Tommie E. Lohman Fluid Measurement Laboratory
Contact: Dr. Rashid Hasan
Primarily used for teaching, this laboratory is used for short research testing, and provides equipment and procedures for the physical analysis of oilfield fluids including oilfield emulsions, water and sediment in oils, and gas and liquid metering. A working water well is used in conjunction with the lab for analysis of transient pressure and sucker rod pumps. As an instructional facility, its main focus is for production engineering where students are trained in the acquisition and evaluation of fluid data with an emphasis on development of procedures for handling oilfield fluid samples. LohmanLab_1.jpg LohmanLab_2.jpg

Equipment and experiments include:

- Two gas “reservoirs” of 120-gallon volume, each outfitted with accurate pressure gauges and mass flow meters so that two teams of students can perform P/Z reservoir depletion and projected ultimate recovery experiments simultaneously.
- Two Fluid Friction Pressure stations for measuring liquid friction pressure drops through various sized pipe with different surface roughness, including effects of pipe bends and presence of valves and similar flow restrictions. The experiments are relevant to design of well tubing, surface piping and related hardware.
- Two Gas-Liquid two phase flow loops with 3-inch, 2-inch and 1-inch clear piping for determining two-phase flow regimes in horizontal and vertical flow. In addition to setting up various flow regimes by varying air and water throughput, students relate the various regimes to such diverse phenomena as gas lift, liquid holdup/loading and slugging problems during production.
- Two Twin Centrifugal Pump benches. The two pumps on each bench can be arranged singly, in parallel (mimics high flow rate/low pressure drop of liquids at the surface) and in series (mimics two stages of an electrical submersible pump). Experiments lead to computation of pump efficiency, pressure head, horsepower, recommended operating range and effects of added pump stages. Limitations of C-pumps, such as cavitation and loss of prime are also examined.
- Three phase separator benches. The acrylic separators are transparent so that students can design and observe efficient separation of air, water and hydraulic oil as well as process upsets such as emulsion formation and carryover. Fluid input flow rates are measured with pitot tube (air), turbine meter (water) and gear meter (oil). Separated liquid drainage rates are measured with sonic meters attached to drain lines.

In addition to the above equipment with two workstations each, the lab’s gas flow loop with three spools containing different size orifice plates has been upgraded with upstream and downstream variable chokes, mass flowmeter, and Barton gauges so that students can become familiar with methodology of field gas flow measurement.
Distributed acoustic sensing (DAS) data is currently being used to monitor flow events. DAS data can identify where fluid is being produced from a perforation or hydraulic fracture and it can be used to qualitatively determine where fluid is being injected into the formation during the hydraulic fracturing process. DAS data however has not been used to quantify these flow rates.

The acoustic lab is currently working to understand how acoustic data from wellbore sounds can be used to quantify fluid flow rates, fluid distribution during production and injection, and fluid saturation. The acoustic lab consists of a simulated hydraulically fractured well. Sound from production into this simulated well is recorded and processed with signal processing components and related to production rates.

The simulated fractured well consists of casing, perforation tunnel and a proppant filled fracture. The casing is 4 ft long, and has an outer diameter of 5 1/2-in and inner diameter of 4 7/8-in. The perforation tunnel has a diameter of 0.5-in. The proppant filled fracture has a width of 0.2-in., length of 2-ft and height of 1-ft. The proppant filled fracture is connected to the well through the perforation tunnel. Fluid is injected into one end of the fracture and is produced into the well through the perforation tunnel. The signal processing components consist of a B&K type 8103 hydrophone, a Nexus conditioning amplifier, NI-9234 data acquisition device, Labview, and Matlab software.