Reservoir Surveillance Fundamentals Lab Work

Compliments of Intertek Westport
Houston Laboratory
Lab Work for PEs and Background to ARE Course

Lab Work
- Geochemistry
- Phase Behavior
- Miscibility/Immiscibility of Displacement
- Flow Assurance
- Core Analysis
- Geology/Petrology
- SCAL
- EOR/IOR
- Relative Flow
Geochemistry

Petroleum Geochemistry
- Geochemical Correlations
- Oil Fingerprinting/Reservoir Continuity
- Source Rock Analyses
- Generation, Migration, Accumulation, Alteration
- Tar Mat/Oil Quality Distribution
- Leak and Fluid Loss Evaluation

Inorganic Geochemistry
- Chemostratigraphy
Geochemistry

- Analytical Services HPLC
- Chromatography
  - Extended Gas - Hydrocarbons to C13+, CO₂, Nitrogen, Oxygen
- Whole Oil to C90+
- ICP/MS
  - Whole Oil Elemental Analysis
  - Whole Rock Elemental Analysis
  - Water Analysis
- Laser Induced Breakdown Spectroscopy
  - Whole Rock Elemental Analyses
- GC Mass Spec
  - Biomarkers
- Isotope Mass Spectroscopy
  - Carbon and Deuterium
Phase Behavior / PVT

Reservoir Fluid Studies
- Sample Validation
- Black Oil Studies
- Volatile Oil Studies
- Gas Condensate Studies

Advanced PVT Studies
- Swelling Tests (P-x Diagram)
- Multiple Contact Tests
- Slimtube Experiments
Determine the minimum pressure required to have a certain amount of injection gas dissolved in the original oil in place.
Swelling Factor and Other Volumetric Parameters

Swelling of the oil phase causes:

- Breakdown of the original capillary equilibrium,
- Pore-scale redistribution of the phases.
Determination of Dynamic MMP or MME

\[ y_i^{\text{inj}} = \text{Variable, or} \]
\[ P = \text{Variable} \]

- Gas injected, in PV
- Oil Recovery, %
- Oil Recovery after 1.2 PV, %
- Pressure or \( y_i \), (-)

MMP or MME
Multi-contact Experiment determines the miscibility mechanism and the level of IFT at operating pressure.
Flow Assurance

Gas Hydrate Studies

- Gas Hydrate Prediction and Inhibition
- Multiphase Fluids, Drilling and Completion Fluids
- Proprietary WHyP hydrate prediction model
- Visual Cell Testing
- Pipeline Testing
- Secure, independent third-party testing of inhibitor systems
Flow Assurance

- Wax and Asphaltene Studies
  - Cross Polarization Microscopy
  - Wax and Asphaltene particle onset using NIR laser light scattering
  - Wax and Asphaltenes Deposition
  - Flow Loop Studies
  - Secure, independent third-party testing of inhibitor systems

- Pipeline Transport Studies
  - Cold Re-start
  - Rheology / viscosity at P & T
  - Computer controlled temperature ramping
Rock Properties / Core Analysis

Routine Core Analysis (SCA-Standard Core Analysis)

- Wellsite handling and preservation of conventional cores
- Gamma Logging
- CT Imaging
- Core Slabbing and Photography
- Basic Petrophysical Measurements
Geology/Petrology Services

- Thin Section Analysis
- Scanning Electron Microscopy (SEM)
- X-Ray Diffraction
- Core Description
- Fracture Analysis
- Formation Damage Prediction
Special Core Analysis (SCAL)

Reservoir Engineering
- Capillary pressure measurements
- Relative permeability measurements
- Reservoir condition core floods measurements

Petrophysical Correlation
- Electrical, Acoustic, and NMR

Formation Damage Studies
- Drilling, Completion and Production Damage

Stimulation
- Geomechanical Properties
- Perforating
Multiphase flow in porous media is controlled by a relatively small number of key parameters, including:

- Reservoir fluid PVT and phase behavior properties
- Interfacial tension (IFT) of in-situ and injected fluids
- Viscosity ratios of flowing fluids
- Reservoir Heterogeneity (Micro-scale and macro-scale pore size distributions)
- The effect of Gravity
- Wettability of the porous media
- Flow velocity
Objectives For SCAL Testing

1. Duplicate your reservoir in the laboratory
2. Duplicate the sequence of events that has occurred in your reservoir
3. Design a test program that accurately models the key parameters that control fluid flow in porous media
   - Phase behavior influences
   - Interfacial tension (IFT)
   - Viscosity ratios
   - Micro-scale and macro-scale pore size distributions
   - Gravity
   - Wettability
   - Flow rate
Procedures for SCAL Testing

- Full Reservoir Condition Testing: Reservoir temperature, reservoir pressure, total overburden pressure
- Wettability: Preserved or restored-state core
- IFT and Viscosity Ratio: Live reservoir fluids
- Composite core stacks of plugs in capillary contact
- Run tests in primary, secondary or tertiary mode
- Use “field-real” flow rates
- Drainage and inhibition tests
EOR/IOR Studies

Gas Injection Studies Field Gas
- CO2 Injection Miscible Gas Injection
- Water Alternating Gas (WAG)

Thermal Recovery Studies Steam Floods
- Steam Floods with Additives

Chemical Flood Studies Polymer
- Alkaline Surfactant Polymer

Consulting
Miscible Gas Injection – EOR

- Advanced PVT experiments and EOS characterization and modeling of fluid phase behavior in the entire (P–V–μ–z_i–K_i–∫_{go}) envelope at Tres

Special Core flood displacement experiments on samples representing the principal reservoir rock types at Tres to:

- Generate \( S_{o,g} \), \( P_c(\sigma_{go}) \), \( K_{ro,w}(S_w) \), \( k_{ro,g}(S_g,\sigma_{go}) \)
- Evaluate the longitudinal dispersion
- Evaluate secondary and/or tertiary recovery processes

Accurate reservoir description combined with compositional simulation to predict process performance and to study design parameters sensitivities.
Relative Flow

Current simulation practices model the reservoir using one set of relative permeability data per rock region. Once rock regions are assigned they are usually fixed over the life of the simulation.
High and Low IFT Relative Permeability

Represents a reservoir scenario where interfacial tension effects dominate and are significant in increasing the recovery of oil.
High and Low IFT Relative Permeability

Case 2 provides an illustration of a reservoir scenario where the mobility, pore size distribution, and wettability effects appear to completely dominate.