Weatherford® LABORATORIES

Unconventional Shale Gas RESERVOIRS

HISTORY

Papers & Presentations

"Unconventional Shale-Gas Systems; The Mississippian Barnett Shale of North-Central Texas as One Model for Thermogenic Shale-Gas Assessment" AAPG Bulletin, v. 91/4, p. 475-499, 2007

"Recent Advances in the Analytical Methods Used for Shale Gas Reservoir Gas-in-Place Assessment" Search and Discovery Article #40317, posted October 30, 2008.

"Shale Gas Core Analyses Required for Gas Reserve Estimates" Fort Worth Society of Petroleum Engineers, 2008

Studies

Thirty-six Basin Studies available for sale including:

- Extended Delaware and Permian Basin Shale Gas Studies
- Ft. Worth Basin Geochemical Database and Report
- Marcellus Shale Gas Study
- Haynesville Shale Gas Study
- Studies in the Montney, Muskwa, Fishscale, Doig Phosphate, Second White Specks and Bakken Formations

SETTING THE STANDARD FOR EVALUATION OF SHALE GAS RESERVOIRS.

While the protocols for evaluating conventional reservoirs were established decades ago, shale gas is just now becoming a viable energy source. As a result, best practices for maximizing its production are highly debated. Even among the best and brightest in our industry, there is broad disagreement about the fundamentals of shale gas science. The truth is, we are in the steep part of a learning curve about how best to analyze—and optimize—these reservoirs.

Despite differences of opinion, however, there is consensus about the importance of these three assessments in the analysis of shale gas opportunities: 1) Thermal maturity and richness; 2) Gas in place; 3) Frac-ability.

Weatherford Laboratories is the only commercial entity in the world that offers all three of these disciplines under one roof. We provide unsurpassed geochemical, sorption properties and rock mechanics measurements—so reliable, in fact, that many of our competitors turn to us to run these tests.

As the shale gas story unfolds, **Weatherford Laboratories** will be at the forefront of the discussion. We agree that better methodologies will evolve, that proven protocols will be established. In the interim, we deliver the most comprehensive shale gas testing available today.

COMPREHENSIVE SHALE GAS TESTING UNDER ONE ROOF.

Wellsite Canister Desorption	→ Aids in quantifying gas in place
TOC, Programmed Pyrolysis and Vitrinite Reflectance	→ Defines organic richness and thermal maturity
Gas Composition Analysis	→ Accurately establishes gas composition and produced gas characteristics
Adsorption Isotherm Analysis	→ Determines the volume of gas that can be stored by sorption at reservoir pressure and temperature conditions
Gas Isotope Analysis	→ Identifies the sweet spots in the basin or reservoir
Petrophysical Attributes (Porosity, Permeability, Saturation, Density)	→ Defines storage capacity and producibility
Mechanical Properties	→ Optimizes hydraulic frac stimulation
Frac and Completion Fluid Evaluation	→ Recognizes potential for rock/fluid formation damage
Field Measurement of In Situ Water Saturation	→ Definitive reserves evaluation by precise measurement of in situ water saturation using radioactive trace coring fluids

INNOVATIONS

Processes

- Slick Water Hydraulic Fracturing Technology
- Ion Milling of SEM Samples for Detailed Porosity and Organic Matter Studies
- Industry Leading Research on Non-Equilibrium (sub-irreducibly saturated) Reservoirs

- Protocol for Using Radioactive Tracer for Saturation Determination from Preserved State Cores
- Wellsite Core Preservation to Ensure Representative Saturations

TURNKEY SERVICES SUPPORT YOUR SHALE GAS PLAYS.

WELLSITE
- Wellsite Personnel for Core Stabilization, Packaging & Transport
- Aluminum 4x4x4 Core Transport Containers
- Portable Wellsite Gamma
- Wellsite Plug Drilling for Saturation Studies

CORE PROCESSING
- Specialized Slabbing Techniques to Optimize Photography and Sedimentological Studies
- Specialized Plugging Techniques to Preserve As-Received Saturations
- Proprietary Procedures to Minimize Evaporation

PHOTOGRAPHY
- High Resolution Core Photography in Multiple Formats

CORE STORAGE & VIEWING
- Core Storage Facilities at 5 Temperatures Ranging from Ambient to Dry Ice
- State-of-the-Art Core Viewing Rooms

PROJECT MANAGEMENT
- Secured Client Websites for Data Retrieval & Archival
- CoreTrac™: Internal Management Information System for Project Tracking, Accessible Worldwide

SHALE GAS LABORATORY TESTS

GEOLOGY
CT Scanning and Evaluation
Scanning Electron Microscopy (SEM)
X-Ray Diffraction (XRD)
Bulk & Clay Mineralogy
Detailed Core & Fracture Descriptions
Thin Section Preparation
Thin Section Analysis
EPI Fluorescence Microscopy

GEOCHEMISTRY
Organic Petrology
- Total Organic Carbon
- Programmed Pyrolysis
- Vitrinite Reflectance

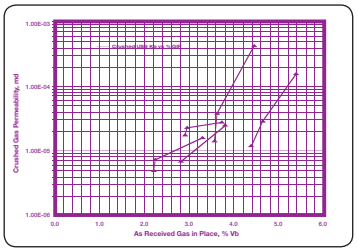
Thermal Extract Gas Chromatography

GAS CONTENT ANALYSIS
Total Gas Content Analysis
Gas Isotope Analysis
Adsorbed Gas Storage Capacity
Free Gas Storage Capacity

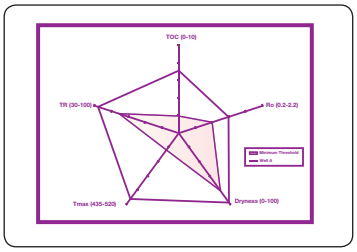
SHALE ROCK PROPERTIES (SRP)
As-Received Mercury Bulk Volume Determination
Fluid and Gas Saturation % PV
As-Received and Dry Gas Filled Porosity % Bv
As-Received and Dry Grain Density
As-Received and Dry Bulk Density
As-Received Pressure Decay Permeability

ADVANCED CORE ANALYSIS
Capillary Suction Time Test
Mercury Injection Capillary Pressure Tests

ROCK MECHANICS
Static Young's Modulus and Poisson's Ratio
Compressional & Shear Wave Velocities
Dynamic Elastic Parameters
Mohr-Coulomb Failure Analysis
Acoustic (Ultrasonic) Velocity Test Compressional (P) and Shear (S) Wave Velocities (1MHz)



Kg vs Gas in Place



Risk Assessment Diagram

EXPECT MORE FROM WEATHERFORD LABORATORIES.

At **Weatherford Laboratories**, we hold fast to Higher Standards. Our purpose is to continually push past conventional solutions to find new and better ways to optimize oil and gas production.

With 38 laboratories around the globe, our team raises the bar for wellsite sampling, core management services, geochemical analyses, and evaluation of traditional and unconventional reservoirs.

At Weatherford Laboratories, we expect more from ourselves so you can expect more from us.

38 LABORATORY LOCATIONS

18 COUNTRIES

1 WORLDWIDE RESOURCE

38 LABORATORY LOCATIONS IN 18 COUNTRIES

NORTH AMERICA
Canada
United States

EUROPE
Norway
United Kingdom

LATIN AMERICA
Brazil
Mexico
Trinidad
Venezuela

MIDDLE EAST / NORTH AFRICA
Kuwait
Libya
Oman
Saudi Arabia
United Arab Emirates

ASIA PACIFIC
Australia
India
Malaysia
Thailand
New Zealand

For contact information, please visit our website:
www.weatherfordlabs.com