

LABORATORIES

UNCONVENTIONAL RESERVOIR CAPABILITIES

Optimizing core handling and
analysis for the efficient, economical
exploitation of unconventional plays

■ **DRILLING & FORMATION EVALUATION**
WELL CONSTRUCTION
COMPLETION & STIMULATION
PRODUCTION


Weatherford[®]

WHEN EXPLORING UNCONVENTIONAL TARGETS,
**EXPERTISE IS
EVERYTHING.**

Unconventional formation evaluation has many operational challenges. Proper core handling—from the time the core reaches the surface until the final analysis—is critical. Shale cores are extremely susceptible to desiccation and fluid loss when exposed to the environment.

At the forefront of innovation in unconventional formation evaluation, Weatherford Laboratories has developed analytical techniques and modified long-standing core analysis procedures for successful application. Our unique handling processes enable us to retrieve more accurate data from unconventional reservoirs.

35 Locations **16** Countries



1 Worldwide Resource





 **Weatherford**[®]
LABORATORIES



Weatherford[®]
LABORATORIES

Wellsite Geoscience Services

QUEST

ACQUIRE PRISTINE CORE DATA

Our Wellsite Services

A core with mechanical damage or fluid loss results in inaccurate data, which can impair decisions on wellbore placement and frac staging. As the industry leader for core-handling innovations in unconventional plays, Weatherford Laboratories has pioneered process, techniques, and equipment to enable efficient sampling and preservation on location.

Wellsite Equipment

ROCKVAULT—This climate-controlled transport and storage container maintains cores at the appropriate temperature, independent of ambient conditions. It also features GPS tracking capabilities and impact monitoring.

BAND SAW—The intrinsically safe band saw cuts both the liner and the core in a single, controlled pass. Rollers on the band saw enable the core to move with minimum shock to the core material. Moreover, by adding no fluids, the saw preserves the natural saturation levels of the core.

MOBILE LAB—Mobile wellsite labs provide on-site services with controlled conditions for plugging, preservation, and photography. Canister desorption and gas sampling services can also be used to provide the most accurate gas quantification numbers possible.

Wellsite Services

WAX PRESERVATION—Our wellsite team uses wax to maintain the in-situ fluid saturations of the core. Core is wrapped in aluminum foil, plastic wrap, and a thermal barrier before being preserved in wax. The thermal barrier prevents the heat of the wax from reaching the core and preserves it for fluid and geochemical analysis.

Isotech RT[®] Pro Service—This wellsite service provides isotopic analysis of C₁ to C₃ gas from the mud system to characterize petroleum system fluids, evaluate safety risks, and assist in diagnosis of completion problems.

PRESSURE CORE HANDLING—Our pressure core analysis delivers accurate results for reserve estimates and enhances understanding of reservoir quality and characteristics. We obtain and analyze cores to provide expanded data sets not available through conventional systems. In combination with the appropriate core analytical program, pressure core handling helps to determine in-situ fluid and gas saturations for reservoir evaluation and resource assessment.

TRACER ANALYSIS—We trace the drilling-mud system to define the amount of filtrate invasion during the coring operations. By quantifying invading fluids, we can determine more accurate oil and water saturation values in the laboratory.

SHIMMING—We place plastic strips in the annulus of the inner tube assembly to lock the core against the inner tube and, in turn, reduce damage during transport.

CANISTER GAS DESORPTION—In this industry field, Weatherford Laboratories has 20 years of experience that includes more than 1,000 well studies, 30 basins, and 200 clients. Canister gas content analysis provides an estimate of gas in place. Live sampling of the in-situ gas characterizes the gas in place, gas isotope geochemistry, and compositional/isotopic fractionation over time.

REVEAL SOURCE ROCK POTENTIAL

Our Exploration Services

In unconventional plays, analyzing the formation and facilitating production requires cutting-edge technology. We provide a variety of industry-leading analyses that help you to appraise reservoir quality, describe depositional environments, define field size and reserves, improve reservoir modeling, and manage risks.

Geochemistry

The study of geochemistry helps us to evaluate geochemical properties, including source richness, thermal maturity, and organic matter type, to enable better predictive modeling of hydrocarbon type and volumetric calculations of in-place hydrocarbons. Our proprietary hydrocarbon extraction methods—such as high-resolution fingerprinting via gas chromatography and mass spectrometry—provide valuable insight into your reservoir. And our isotopic analysis of gases can type the gas to the source and provide thermal maturity and compartmentalization indicators.

ROCK ORGANIC GEOCHEMISTRY ANALYSES

We reduce risks in petroleum exploration and development by using comprehensive geochemical tools to study the formation, migration, and accumulation of petroleum. Our services include evaluating candidate source rocks for past, present, and future production potential and testing reservoir formations for petroleum abundance and quality.

- Drilling-Mud Cleanup
- Total Organic Carbon
- Source Rock Analysis
- Organic Petrology
- Quantitative Extraction
- Fischer Assay

OIL GEOCHEMISTRY ANALYSES

As domain experts in petroleum fluid geochemistry, we can offer a complete range of related analytical services. Our services include the measurement of bulk chemical-physical properties, such as API, viscosity, sulfur content, nickel/vanadium, and SARA. We also offer detailed molecular fingerprinting technologies that include high-resolution chromatography, biomarker analysis by GCMS, and compound-specific isotope analysis.

- High-Resolution Gas Chromatography
- Biomarker Analysis
- API Gravity
- SARA Analysis
- Elemental Analysis

GAS GEOCHEMISTRY ANALYSES

- Gas Composition—This fast, inexpensive method characterizes your gas resources and determines the likelihood of associated hydrocarbon liquids.
- Gas Isotopes—We conduct isotopic analyses on gas samples collected at regular intervals during the drilling operation to enhance understanding of fluids and to recognize the origin of gases (biogenic or thermogenic) and their association with oils.
- Isotope Sampling Products—We use various sampling products—including the IsoTube®, IsoJar® IsoPak®, IsoTrap®, and IsoFlask® systems—developed by IsoTech to address sampling and shipping difficulties and to provide the best possible data.





REVEAL SOURCE ROCK POTENTIAL

Our Exploration Services

Geologic Services

Using a comprehensive suite of analytical and interpretive solutions, we enhance formation evaluation by determining depositional environment, implementing controls on reservoir quality, and improving reservoir modeling. Our geologic services include complete in-house expertise in sedimentology, stratigraphy, petrographic analysis, reservoir characterization, fracture analysis, and biostratigraphy.

- X-Ray Diffraction (XRD) – Whole Rock and Clay Mineralogy
- Scanning Electron Microscopy (SEM)
- Field Emission Environmental Microscopy (FE-SEM)
- Focused Ion Beam – Scanning Electron Microscopy (FIB-SEM)
- Thin Section Photography
- Thin Section Analysis
- Detailed Core Description and Sedimentologic Analysis
- Detailed Fracture Description and Structural Analysis
- Biostratigraphic Services
- XRF/Chemostratigraphy

Petrophysics

Despite the extreme level of heterogeneity in unconventional reservoirs, recent advances in core-scanning technology with nondestructive techniques can give you basic reservoir volume models at an extremely high resolution. Our dual-energy CT (DECT) scanning technologies are unmatched in the industry and provide high-resolution cylindrical unwrapped images, lithology identification, Rhob curves, and Pef curves used to calibrate the downhole logs.

Our advanced high-resolution X-ray fluorescence (XRF) elemental scanning technology goes beyond the capabilities of traditional log-based reservoir models. After acquiring CT scanning and spectral gamma ray data over the core, we can provide lab-based XRF elemental analysis to scan the slabbed surface at a centimeter scale to develop an elemental profile of major and trace elements.

Additional Analytical Lab Services

- Shale Rock Properties
- Adsorption Isotherm
- Effective Gas Permeability
- Effective Oil Permeability
- Coalbed Methane



OPTIMIZE RESERVOIR PERFORMANCE

Our Completion Services

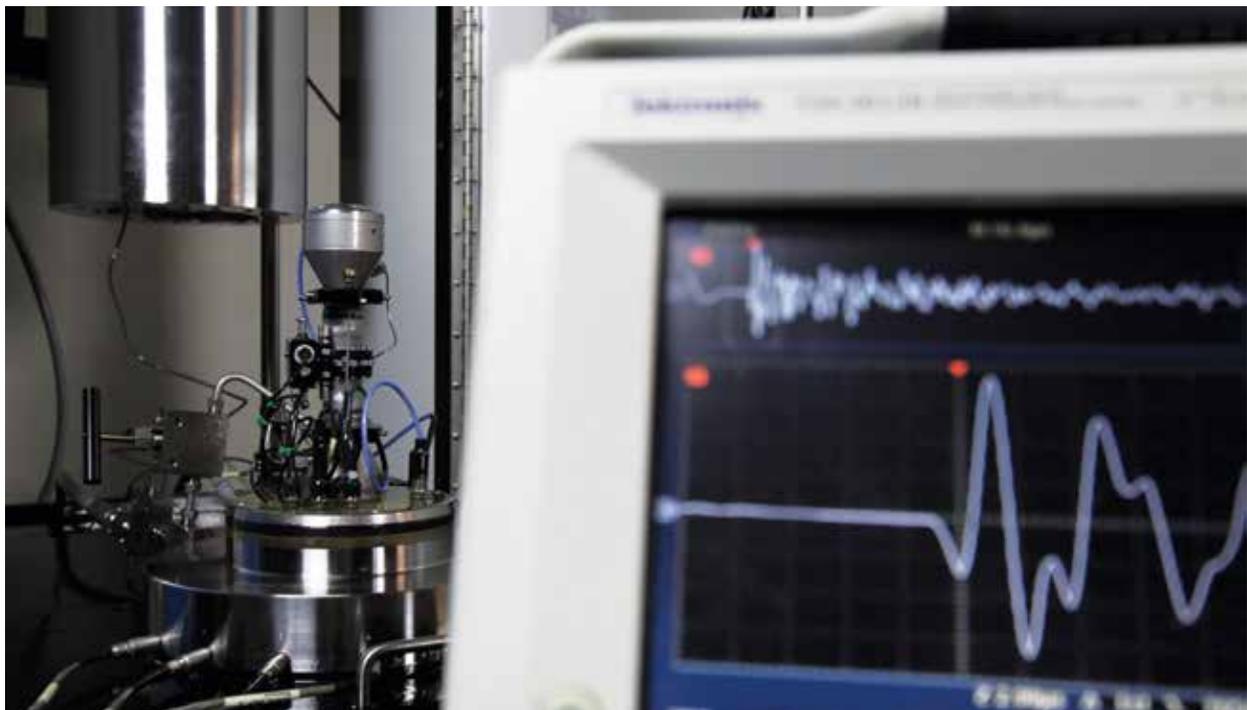
With production success increasingly dependent upon what is known about a reservoir, laboratory analyses help to quantify the unknown and reduce risk. Our experts help to identify pay zones, prevent formation damage, formulate completion strategies, and assist with reservoir stimulation. By reducing reservoir uncertainty, we enhance production and recovery—helping you to produce all economically viable hydrocarbons from your reservoir.

Mechanical Properties

Rock mechanics examines how formation rock responds to imposing forces and affects every aspect of reservoir development. Using a sophisticated high-pressure/high-temperature (HPHT) rock deformation system, our rock mechanics lab provides core-based testing and engineering analysis to enhance production. The data, along with engineering analyses, can help you to avoid costly problems such as borehole instability, casing shear, subsidence, stuck pipe, and sand control issues.

Formation Damage

We recognize that formation damage can threaten the fracture network and overall production of your well. To optimize fluid chemistry for the rock type, we can perform three basic tests: capillary suction time (CST), roller oven disaggregation test (ROT), and linear swell meter test (LST). Each test provides a view of the effects that the rock-fluid interaction has on fluid-sensitive minerals in the formation.





Production Geochemistry

We offer numerous oil geochemistry and oil fingerprinting tools that address various production problems by tracking the individual components of produced oil or gas. These components are natural tracers used to identify the specific reservoir interval that the fluids originate from and the movement of fluids within your field.

PVT

Our pressure-volume-temperature (PVT) capabilities range from sampling to reservoir fluid analysis and crude assay for refinery processes. Our field sampling focuses on obtaining sufficient volumes of representative fluid samples from downhole, wellhead, or separator equipment. We review the layout of your field operation and your analysis goals to select the appropriate sampling method and tools and to identify sound sampling, sample-transfer, and quality-control procedures. Throughout the well life cycle, we collect samples for fluid analysis to guide decisions for production optimization and development planning.

UNCOVER THE GROUND TRUTH

Our Sample Life Services

Rock, fluid, and gas samples reveal the true character of geological formations—whether you're prospecting for oil and gas or confirming development decisions. At Weatherford Laboratories, we've developed sophisticated systems to store, track, and protect samples so that you can review and re-evaluate them as new developments occur.

Sample Storage

Protecting your samples is our number one priority. We offer five storage environments—ambient, air conditioned, chilled, freezer, and dry-ice facilities—for your core material. We also provide storage for fluid samples at live reservoir or ambient conditions. Our DOT-certified fluid sample containers offer cost-effective storage compared to the use of downhole chambers, and they can be transported as requested. We track your samples by means of sophisticated data management systems.

Dedicated Project Management Team

The Weatherford Laboratories Project Management team is your direct connection to the lab. This team develops an analytical plan with you and delivers the answers you need. Your project manager acts as your main point of contact through all program phases. Our proprietary CoreTrac project management software documents all critical client and project information, disseminates and tracks testing details and procedures, manages program estimates and costs, and protects program information.

Core Viewing Facilities

As part of the core analysis program, each core viewing room contains everything you need to evaluate the rock: white and UV lighting, petrographic scopes, spray bottles, hydrochloric acid (HCl), office supplies, wireless Internet service, and computers. We also provide access to media and conference rooms.

Secure Web-Based Data Portal

As the lab generates data and images for each of your projects, you can view and download them using our secure, web-based client portal..

KEY ADVANTAGES OF THE CLIENT WEBSITE

- Access data anytime, anywhere with a personal computer
- Retain an offsite archival copy of your data
- View data dynamically
- Choose from available viewers for custom data types:
 - Thin section/scanning electronic microscopy viewer
 - CT viewer
 - Panorama

Core Storage Capacity

Freezer	1,680 ft ³
Chiller	2,883 ft ³
Ambient	105,042 ft ³
Core Viewing	5,406 ft ³
Total Capacity	115,011 ft³




Weatherford
LABORATORIES

Our laboratories have a
**COMMITMENT TO
HIGHER STANDARDS**

Our team continually pushes past conventional solutions to find new and better ways to optimize oil and gas production. Throughout our history, we have continually expanded our capabilities, perfected our processes, and enhanced our analyses to serve you better.

We combine a superior global team of geoscientists, engineers, technicians, and researchers with the industry's most comprehensive, integrated laboratory services. Located in 16 countries, our worldwide laboratories set higher standards for wellsite sampling, core management services, laboratory analyses, and evaluation of offshore reservoirs.

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





ASIA PACIFIC

Brisbane, Australia

Telephone: +61.7.3482.9900

Email: APIInquiries@weatherfordlabs.com

CANADA

Calgary, Alberta

Telephone: +1.403.736.3500

Email: NAInquiries@weatherfordlabs.com

EUROPE/WEST AFRICA

UK, Norway

Telephone: +44.1342.317310 (UK),

+47.51.81.66.00 (Norway)

Email: EuwebInquiries@weatherfordlabs.com

LATIN AMERICA

Rio de Janeiro, Brazil

Telephone: +55.21.3505.9400

Email: LAINquiries@weatherfordlabs.com

MIDDLE EAST/NORTH AFRICA

Abu Dhabi, UAE

Telephone: +971.2.6989079

Email: MENAINquiries@weatherfordlabs.com

UNITED STATES

Houston, Texas

Telephone: +1.832.237.4000

Email: NAInquiries@weatherfordlabs.com



Explore your unconventional targets with innovators in formation evaluation. Weatherford Laboratories offers a global laboratory network and dedicated professionals that enable you to extract maximum value from your core, fluids, and gas samples.



weatherford.com



twitter.com/weatherford



youtube.com/weatherford



facebook.com/weatherford

Weatherford products and services are subject to the Company's standard terms and conditions, available on request or at weatherford.com. For more information contact an authorized Weatherford representative. Unless noted otherwise, trademarks and service marks herein are the property of Weatherford and may be registered in the United States and/or other countries. Weatherford products named herein may be protected by one or more U.S. and/or foreign patents. Specifications are subject to change without notice. Weatherford sells its products and services in accordance with the terms and conditions set forth in the applicable contract between Weatherford and the client.

IsoFlask, IsoJar, IsoPak, Isotech RT, IsoTrap, and IsoTube are registered trademarks of Weatherford in the US.