



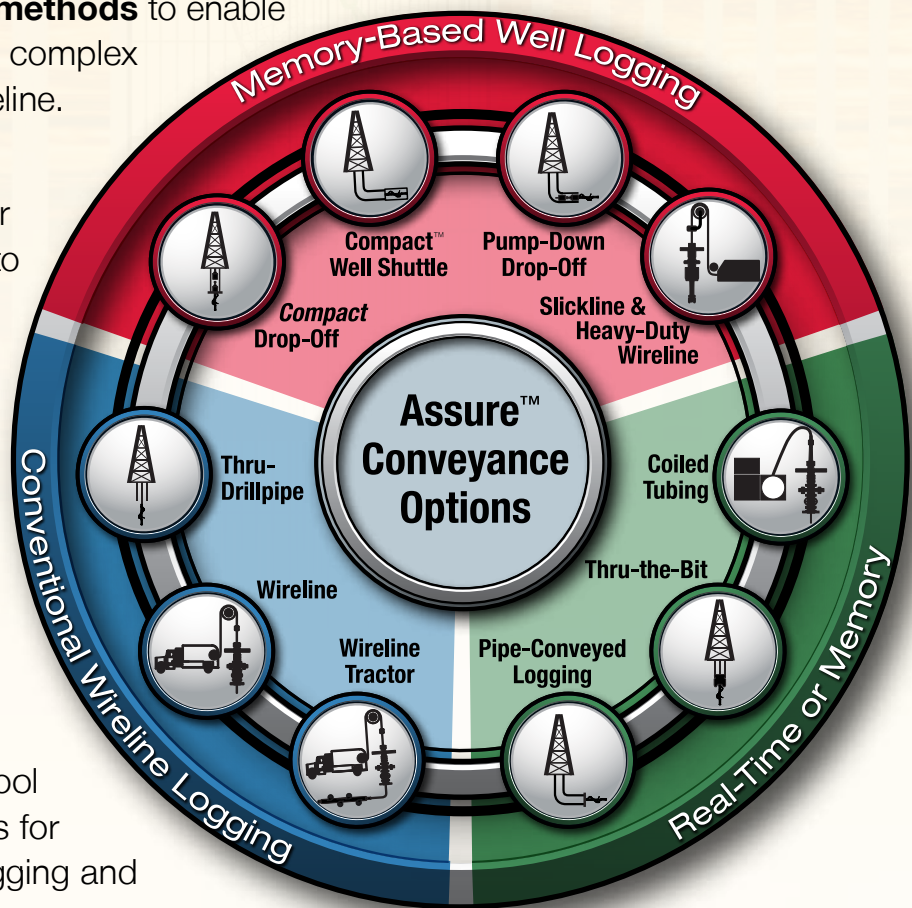


# Innovation assured.

With more than 40 years of experience in the design, manufacture and operation of openhole logging technologies, we offer **10 distinct conveyance methods** to enable logging in routine to highly complex wells—with or without wireline.

This multitude of delivery options enables us to tailor data-acquisition programs to your specific well in a way no other service provider can. The resulting benefits range from reduced risk—of both tool loss and failure to obtain data—to significant cost savings.

Beyond logging in open holes, many of our *Assure* conveyance systems can also be used to optimize tool deployment in cased holes for perforating, production logging and other applications.





## Multiconveyance logging comes of age

Wireline has been the primary method of tool deployment throughout most of the decades-long history of logging. Times have changed. Today's boreholes are decidedly longer, less vertical and more deviated, challenging efforts to obtain logs through conventional means.

Assure systems enable you to obtain a full spectrum of logs—cross-dipole sonic, imaging, formation pressure, lithology, porosity, natural gamma ray and resistivity—even in complex trajectories. In turn, the data inform critical operational decisions.

### The Assure Advantage

- **Reduced risk** of stuck tools, lost-in-hole and associated costs
- **Reliable tool deployment to logging depth and reliable data acquisition** when dogleg severity is high, with less risk of bridging events
- **Freedom from constraints** that conventional logging imposes on well design in general and logging in slim holes
- **Minimal personnel and equipment requirements**—especially advantageous in remote locations
- **Smaller footprint** permits logging out of a suitcase with no units, ideal for space-constrained environments



# Flexibility assured.

We offer 10 distinct techniques for conveying logging tools into open holes. These include conventional, conventional with memory and advanced memory logging. This breadth enables us to minimize data-acquisition costs and risks.





## Assure Conveyance Options

	High-angle/ horizontal geometries	Rigless operations	Drilling rig operations	Real-time acquisition	Memory acquisition
Wireline		✓	✓	✓	✓
Thru-drillpipe			✓	✓	✓
Wireline tractor	✓	✓	✓	✓	✓
Drop-off			✓		✓
Pump-down drop-off	✓		✓		✓
Compact™ well shuttle	✓		✓		✓
Slickline/heavy-duty wireline		✓	✓		✓
Coiled tubing	✓	✓	✓	✓	✓
Thru-the-bit			✓	✓	✓
Pipe-conveyed	✓		✓	✓	✓



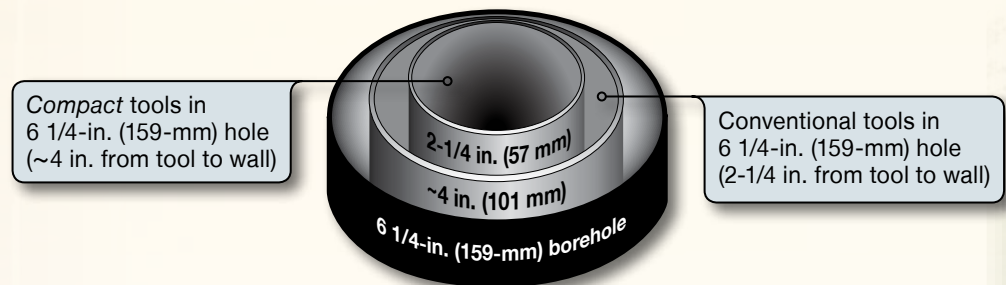


# Wireline: Enhancing Conventional Logging

Our *Assure* portfolio includes all conventional wireline-based conveyance techniques, ideally suited for real-time logging in less deviated, vertical wells. Our *Compact* tools enhance this conventional approach; their smaller diameter reduces the risk of bridging and enables **thru-drillpipe conveyance**.

This wireline-based technique entails lowering tools through open-ended drillpipe to bypass impediments, such as ledges or washouts, enabling logging in the lower sections of a well while minimizing risk exposure. Similarly, specialized **Compact logging bits** enable you to lower tools through the bit in difficult hole conditions.

While a **wireline tractor** can be used to deploy logging tools in open holes, it is more commonly used in cased-hole applications; the technique is especially well suited for production logging, enabling precise control of the speed at which the tools are pulled out of the hole.



Compact logging tools have a much smaller OD than conventional logging tools, reducing the risk of bridging.







# with Compact™ Technologies

## Wireline Conveyance Techniques in the Assure Portfolio

Standard

Thru-drillpipe

Tractor



### Study Shows Wireline-Conveyed Compact Tools Reduce Bridging Incidents by 50%

#### Western Canada

A study conducted in collaboration with PSAC (Petroleum Services Association of Canada) compared Compact tools with conventional tools. During the study, a total of 17,849 wells were logged between 1997 and 2003. With their significantly smaller ODs, Compact tools reduced bridging by 50%.

### Compact Tools Deployed on Wireline Save Operator US\$55,000

#### Texas, USA

After downhole conditions thwarted another service provider's two previous attempts to log a well, Weatherford successfully acquired logs with Compact tools deployed on wireline. The approach saved more than US\$55,000 in additional pipe-conveyed logging costs and an estimated 24 hours of nonproductive time.

### Thru-Drillpipe Technique Enables Logging Tool Conveyance, Data Acquisition Despite Tight Wellbore Restriction

#### Thailand

Compact logging tools deployed on wireline using the thru-drillpipe method enabled acquisition of high-quality logs and formation-pressure testing data in challenging hole conditions. The Compact tools' smaller OD allowed operators to pass through a tight, 3 1/2-in. wellbore restriction.

REAL  
RESULTS

# Conventional + Memory: Expanding Logging Capabilities with Memory Feature

We have enhanced several conventional conveyance methods with **memory logging**: recording data downhole against time in memory mode to subsequently produce a log at surface through a time/depth conversion process. The resulting log is comparable in quality to logs obtained through conventional methods.

Conventional methods enhanced with memory capability include **coiled-tubing** and **pipe-conveyed logging (PCL)**. This feature makes pipe-conveyed logging possible in extremely slim holes (as small as 3-7/8 in.). Similarly, it renders coiled-tubing logging possible even when the coiled-tubing unit does not have a wireline cable (a typical scenario), thereby minimizing costs. When run conventionally, enabling real-time data acquisition, our unique PCL system has a high power rating and high salinity-handling capability.

## Conventional + Memory: Enhancing Conventional Logging with Memory Capability

Coiled tubing

Thru-the-bit

Pipe-conveyed

### Compact Logging Tools Run in Memory Mode Provide Operator with Data Critical to Well Completion

#### Kingdom of Saudi Arabia

Run on 2 3/8-in. drillpipe, *Compact* logging tools—dual-neutron (MDN) and photo density (MPD)—enabled an operator to obtain formation data critical to completing a slim 3 7/8-in. well. The memory feature made logging without wireline possible, ensuring a safe and efficient operation with full well control.

#### Deploying *Compact* Micro Imager in Memory Mode Saves 24 hours in Rig Time

##### Abu Dhabi

Weatherford successfully deployed its *Compact* micro imager (CMI) attached to the end of a drillpipe during a scraper run in a horizontal well. The CMI was able to reach TD and logged the interval from 7,770 ft (2,368 m) to 4,725 ft (1,440 m) measured depth (MD) in memory mode. The operator saved nearly 24 hours of rig time and associated costs by combining the image logging run with the scraper run. The CMI produced a high-quality image of the formations, enabling the operator to obtain a better understanding of the reservoir.

REAL  
RESULTS





# Advanced Memory Logging: Mitigating Risks Associated with Conventional Wireline

Our advanced memory logging techniques are ideally suited for wells with extremely complex trajectories, poor hole conditions and/or impassable zones. They include our Compact™ well shuttle and Compact drop-off techniques, as well as the pump-down drop-off method.

When logging with the **Compact well shuttle**, tools are protected inside the drillpipe during tripping and deployed into the open hole after reaching total depth. The technique enables rotation, reciprocation and circulation of the drillpipe, as needed, to accommodate specific well conditions. Logging with the Compact well shuttle is particularly advantageous in extended-reach wells; the technique permits data acquisition in a single pass, versus the multiple passes required during conventional pipe-conveyed logging.

Especially pertinent in challenging boreholes, the **Compact drop-off (CDO)** technique entails lowering an open-ended drillpipe with a special bottomhole assembly (BHA) to the bottom of the well. Compact tools are then conveyed on wireline through the pipe and released into the BHA's landing sub. As with the well shuttle, they acquire data in memory mode when the drillpipe is tripped to surface. At any time during this operation, the tools can be retrieved with wireline.

The **pump-down drop-off** technique integrates CDO with special seals and pistons to push logging tools to the desired depth in highly deviated or horizontal wells. Should the drillpipe become stuck, the tools can be retrieved at any time. At the end of the data-acquisition run, the tools are latched and brought to surface on wireline prior to tripping out of the hole.

## Memory Logging Techniques in the Assure Portfolio

Compact well shuttle

Compact drop-off

Pump-down drop-off

Slickline/heavy-duty wireline



### Compact Well Shuttle Saves CAN\$100,000, Enhances Safety in Deviated Sour Well

#### Alberta, Canada

Safety was paramount in logging a deviated, sour well near a residential area. The well shuttle not only transported Compact tools safely and efficiently, but also eliminated additional costs associated with a well blowout prevention plan required with traditional wireline operations. Savings totaled more than CAN\$100,000.

### Compact Well Shuttle Overcomes Complexity of Horizontal Well Trajectory

#### Tarim, China

In a kickoff and horizontal section with a complex trajectory, a tool-push logging system had failed to reach total depth after six runs spanning 22 days. A Compact well shuttle transported Compact gamma ray, array induction and sonic sonde tools to obtain a complete data profile in 45 hours—at just 10% of the total cost of the failed attempts.

### Wireline Drop-Off Enables Acquisition of Key Data

#### Caquetá, Colombia

Two highly deviated and challenging exploratory wells had severe caving throughout the openhole sections. An attempt to run logging tools on wireline ended in bridging. Weatherford's drop-off method subsequently enabled the conveyance of Compact cross-dipole sonic (CXD) and Compact micro imager (CMI) tools. As a result, the client was able to acquire data critical to designing a drilling plan.

**REAL  
RESULTS**

# Optimizing Memory Logging

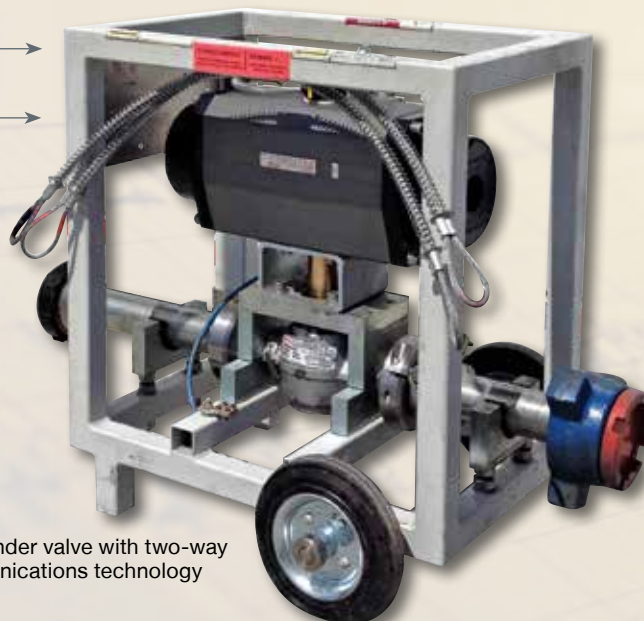
Drawing on our extensive experience in memory logging, we incorporate a number of innovative technologies to minimize the risk of performance failure, improve data quality and enhance safety during operations by eliminating wireline.

Used with the CDO method, **Compact™ logging bits** help ensure that you reach your desired depth. These unique bits are available in standard sizes—5-7/8, 7-5/8 and 8-1/2 in.—and can be custom-designed as well.

**Two-way impulse communications technology** confirms that tools are performing properly downhole when recording in memory mode with the *Compact* well shuttle, ensuring quality control. It transmits instructions to logging tools using mud pulses. Applications include tool checks and pressure testing with the *Compact* formation tester (MFT), with feedback on pretest quality sent to surface.

The **shuttle commander valve** eliminates risks associated with manual mud pulsing, such as spikes above the pressure band, and helps ensure that the well shuttle's impulse communication system functions properly.

A specialized **downhole float valve** prevents mud from ascending the drillpipe during drop-off and pump-down drop-off jobs, minimizing the risk of a well-control incident. Its unique design allows tools to pass in both directions.



Shuttle commander valve with two-way impulse communications technology



Downhole float valve





# Reliability assured.

We couple logging and conveyance technologies with associated expertise to select the optimal tools for an operation. A thorough, prejob risk assessment is standard procedure. We use specialized software applications to analyze mechanical and hydraulic forces from surface to total depth, ensuring that the tool string can pass safely through the well trajectory.

Other factors taken into account include tension estimates and the potential impact of adverse conditions, such as swelling shales, creeping salts, large washouts and ledges.

**Beyond quantitative modeling.** Traditionally, conveyance selection has relied primarily on quantitative modeling. Such models only enable prediction of tension profiles to inform wireline selection or to rule out wireline as a viable option. We look beyond quantitative factors to borehole conditions, enabling us to select the most appropriate, cost effective conveyance method for your well.

## Basic Assure Conveyance Selection/Risk Assessment Model



Weatherford goes beyond quantitative analysis to select the most appropriate conveyance method for your needs to ensure the delivery of a log.

# Data quality assured.

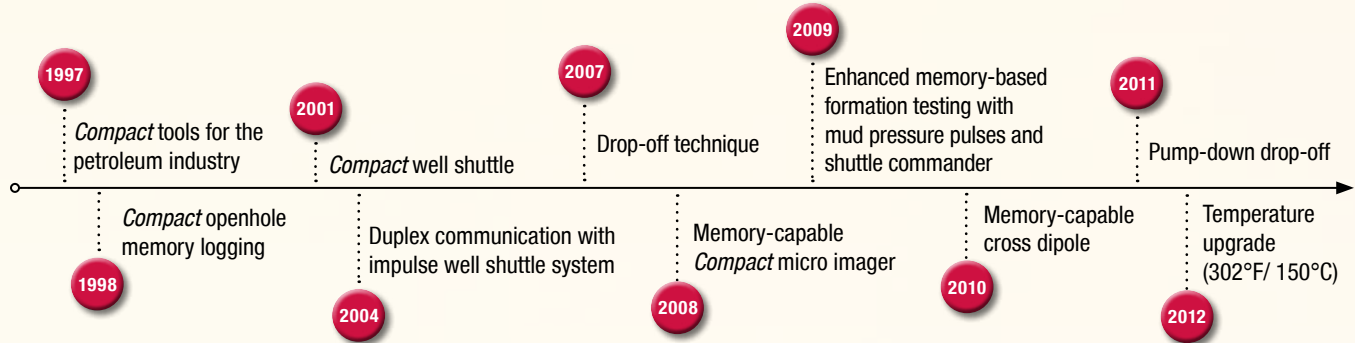
Our Assure™ conveyance technologies work with our renowned Compact™ logging tools. Since their introduction to the petroleum industry in 1997, operators throughout the world have relied on our *Compact* tools to make informed decisions. They have a significantly smaller outside diameter than their conventional counterparts, allowing them to bypass restrictions and well sections with high angular buildup rates that inhibit conventional tools. *Compact* tools were designed to be conveyed through multiple means, further ensuring acquisition of logs, even in challenging well trajectories.

Our dedicated wireline R&D complex in East Leake, UK houses the CALLISTO (calibration and in-situ tool optimization) testing facility, jointly owned with Leicester University. Here, we calibrate logging tools that measure porosity against standards that have been independently verified. This ensures reliable, highly accurate porosity measurements.





## The Compact™ story: A history of innovation



## The Compact family

### Resistivity

#### Array induction (MAI)

Provides five depths of investigation in a wide range of fluid resistivities

#### Dual-laterolog (MDL)

Ideal for wells drilled with high salinity, water-based muds in high-contrast ( $R_f/R_m$ ) environments

#### Micro resistivity (MML/MMR)

Provides flushed-zone resistivity measurements with high vertical resolution

#### Shallow-focused electric (MFE)

Offers high vertical resolution in conductive mud environments

### Porosity and Lithology

#### Photodensity (MPD)

Provides porosity/lithology in open and cased holes

#### Dual neutron (MDN)

Applicable in air- and mud-filled environments (open and cased holes)

### Natural Gamma Ray

#### Gamma ray (MCG)

Features casing-collar locator and telemetry

#### Gamma ray (MGS)

Standalone natural gamma ray detector, which can be placed anywhere in the tool stack

#### Spectral gamma ray (SGS)

Identifies clay types, helps determine permeability

### Acoustic

#### Compact cross-dipole sonic (CXD)

Provides data for a wide variety of geophysical, petrophysical and geomechanical applications

#### Sonic sonde (MSS)

Provides secondary porosity and lithology, formation mechanical properties and fracture detection

#### Ultrasonic gas detector (MGD)

Uses dual-detector to identify flow of gas into a well

### Formation Imaging

#### Compact micro imager (CMI)

Minimum OD of just 2.4 in. (61.0 mm); can be deployed in memory mode

### Formation Pressure Testing

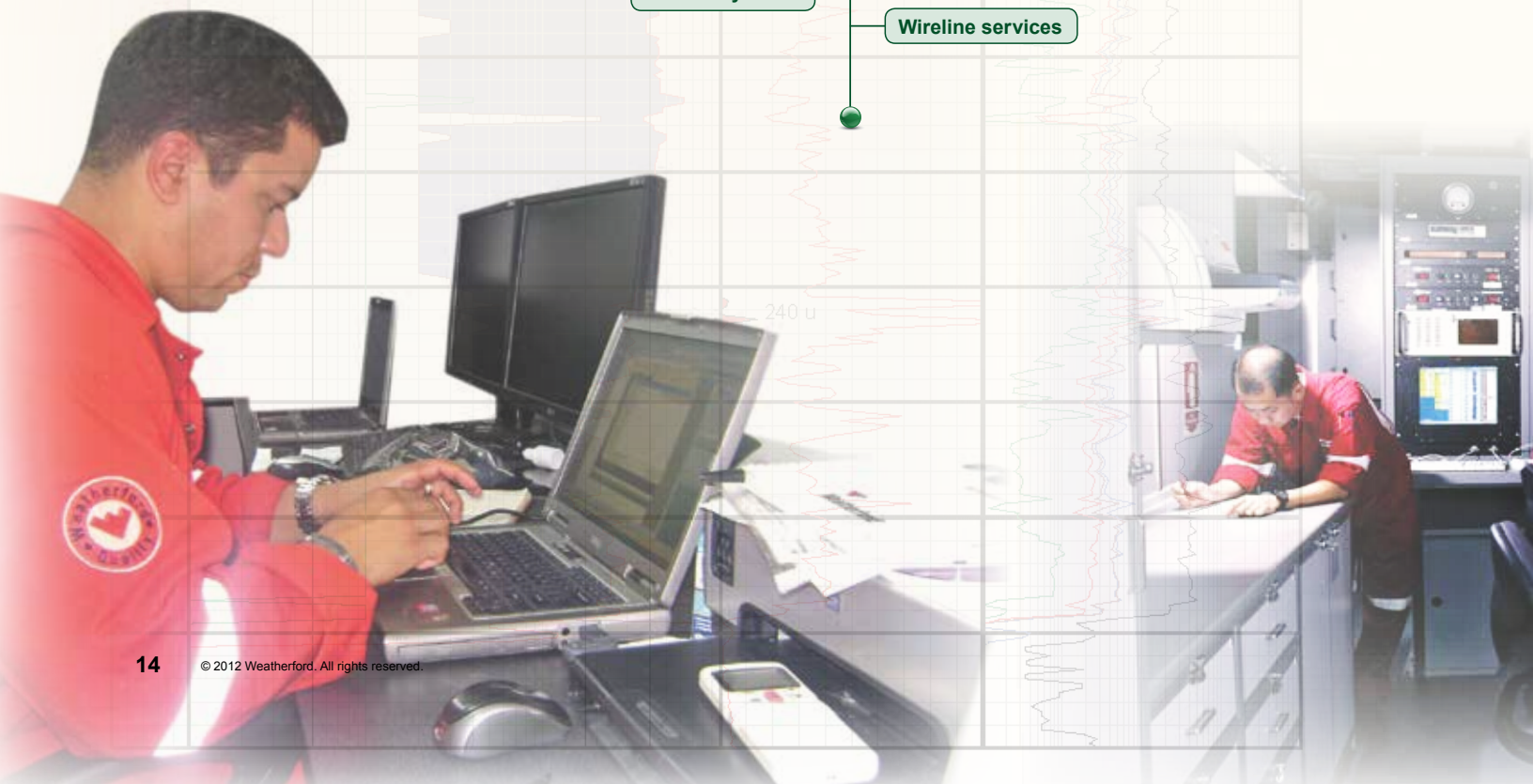
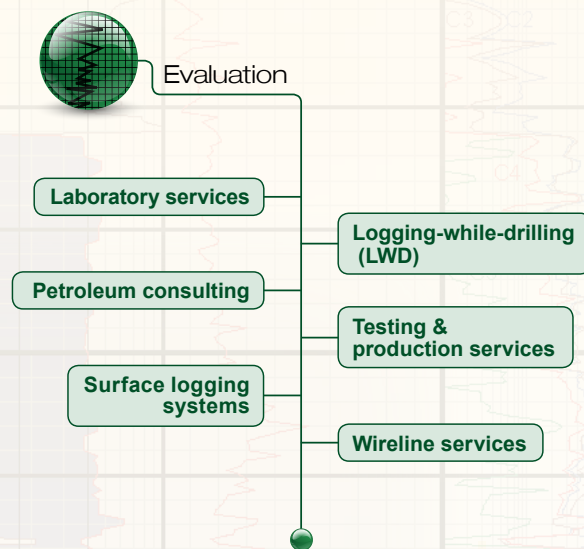
#### Formation pressure tester (MFT)

Smaller, lighter and easier to operate than conventional formation pressure testers

# Formation evaluation expertise

Weatherford is one of the world's largest providers of openhole and cased-hole wireline services. We also offer a wide range of associated formation evaluation services, including laboratory services (such as core sample analysis), logging-while-drilling and surface logging.

And we have an interdisciplinary team—Petroleum Consulting—that performs a number of functions, including data processing and interpretation, and integrated field studies to help you get the most out of your formation evaluation data.







assured.



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Assure™ Conveyance Systems

To learn more about mitigating risks to obtain reliable logs—even in complex boreholes—with our *Assure* conveyance/Compact™ logging combo, contact your local Weatherford representative or visit [weatherford.com](http://weatherford.com).



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