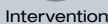
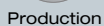
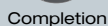
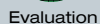
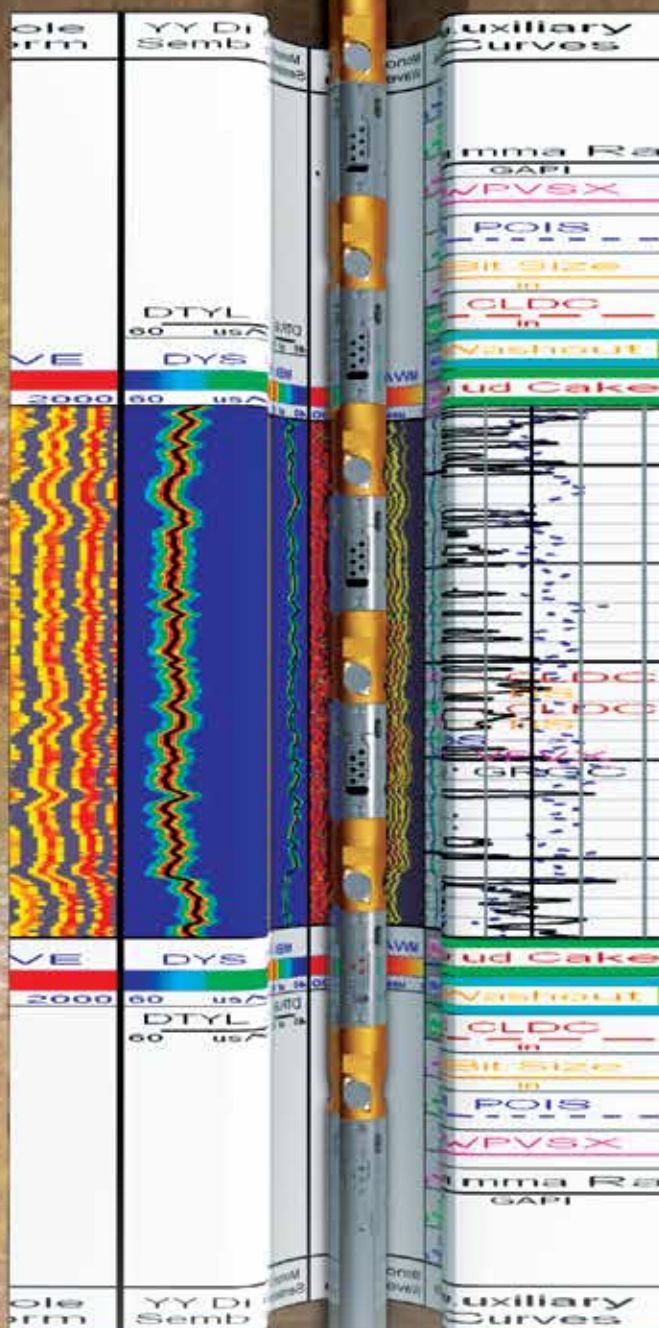
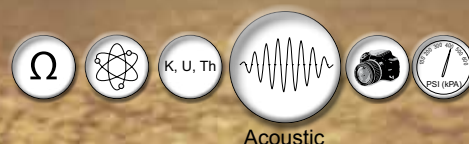




Compact™ Cross-Dipole Sonic (CXD)



Wireline services

- **Cased-hole**

- Casing inspection
- Cement evaluation
- Formation evaluation
- Intervention
- Perforating
- Production logging
- Propellant stimulation

- **Microseismic services**

- **Openhole**
 - Acoustics
 - Formation testing
 - Imaging
 - Nuclear magnetic resonance
 - Porosity/lithology
 - Resistivity

- **Subsurface evaluation services**

More options. More service.

Offering *Assured* delivery of acoustic data and solutions—regardless of borehole conditions

Assured access to acoustic data

A new generation CXD tool—the Compact™ cross-dipole sonic (CXD)—was recently added to Weatherford's exclusive *Compact* fleet of logging tools. The *Compact* CXD tool is the industry's only 2 1/4-in. monopole/cross-dipole sonic tool that can be deployed with or without wireline to acquire compressional, shear-slowness and fast-shear azimuth.

By combining tool configuration flexibility, multiple deployment options and memory capability, our *Compact* CXD tool delivers key data for seismic velocity models and has applications in a broad range of drilling, completions and production challenges related to rock deformation.

The unique *Compact* CXD tool provides options to acquire acoustic information in all routine to challenging wellbores using our **Assure™ conveyance options**.

Assured applications

Geophysics

- Surface and borehole seismic correlation
- Amplitude variation with offset (AVO) analysis

Petrophysics

- Porosity estimation, lithology and clay identification
- Gas identification

Geomechanics

- Anisotropy presence, amount and orientation
- In-situ stress orientation
- Pore pressure
- Wellbore stability modeling
- Hydraulic fracture design
- Natural fracture identification and orientation
- Sand production in unconsolidated formations
- Stoneley wave permeability estimates
- Optimize well placement for maximum reservoir drainage

Added benefits of the small-diameter CXD

- The tool can be run through the tubing into existing cased or barefoot completion wells—saving the costs of pulling the tubing that is required when running conventional cross-dipole acoustic tools.
- It can be run in small internal-diameter, cemented casing—where conventional cross-dipole acoustic tools either cannot be run or risk getting stuck.
- The high-strength isolator and rugged mechanical tool design of the CXD delivers low-risk *Assure* conveyance in horizontal wells. Earlier conventional acoustic tools were mechanically weak, which meant there were significant risks when conveying the tools into horizontal wells.
- The CXD tool is fully combinable with the *Compact* micro-imager (CMI) and other *Compact* tools that complement the evaluation techniques and applications derived from the cross-dipole data.





Assured reservoir productivity

Weatherford's *Compact* CXD tool, combining monopole and cross-dipole sonic technology, provides acoustic data for a wide variety of geophysical, petrophysical and geomechanical applications. The data obtained by the CXD tool assists in improving reservoir characterization and ultimately maximizes well and reservoir productivity.

The unique profile and length of our CXD tool facilitates flexible deployment—in wireline or memory mode—to mitigate the risk of bridging events and reduce nonproductive time.

Maximizing well and reservoir productivity

Borehole cross-dipole acoustic data has many applications in hydrocarbon exploration, appraisal and production. Cross-dipole acoustic applications that create significant economic value include:

- Determining reservoir extent through surface and borehole seismic correlation
- Recommended drilling practices, borehole stability prediction and well placement from the rock mechanical properties and stress-field analysis
- Optimizing field development, completion designs and perforation programs for maximum well drainage using stress-orientation analysis
- Formation and reservoir characterization—determining the location, orientation and intensity of natural fractures from the azimuthal anisotropy
- Evaluating hydraulic fractures—providing the direction, vertical extent and degree of induced fracture anisotropy from rock mechanical properties and azimuthal anisotropy

Shear-wave anisotropy measurements are sensitive to formation stresses, fracture density and directions. Knowing the azimuthal anisotropy enables production optimization by planning the well placement to encounter as many fractures as possible.

The azimuthal anisotropy from the CXD tool is excellent for determining the maximum stress direction even when formation failure or wellbore breakouts are not evident on borehole image or caliper logs.

Mechanical rock properties from the CXD tool can predict formation strength and potential sanding problems. Stoneley wave reflectivity analysis from the CXD tool can identify natural permeable fractures. This information enables the planning of the best intervals and direction to perforate and maximize production in vertical and horizontal wells. The stress orientation analysis can help predict the maximum sand-free drawdown pressures.

Our CXD tool has a proprietary transmitter and receiver design that produces high-quality data for a broad range of environmental conditions. It has three high-powered transmitters—one monopole and two wideband, low-frequency, dipole transmitters perpendicular to each other.

The receiver section has an array of eight receiver stations. Each station consists of four gain-matched, piezoelectric hydrophones that are aligned with the dipole transmitters. Ninety-six, high-fidelity, wideband waveforms are recorded, ensuring excellent quality control.

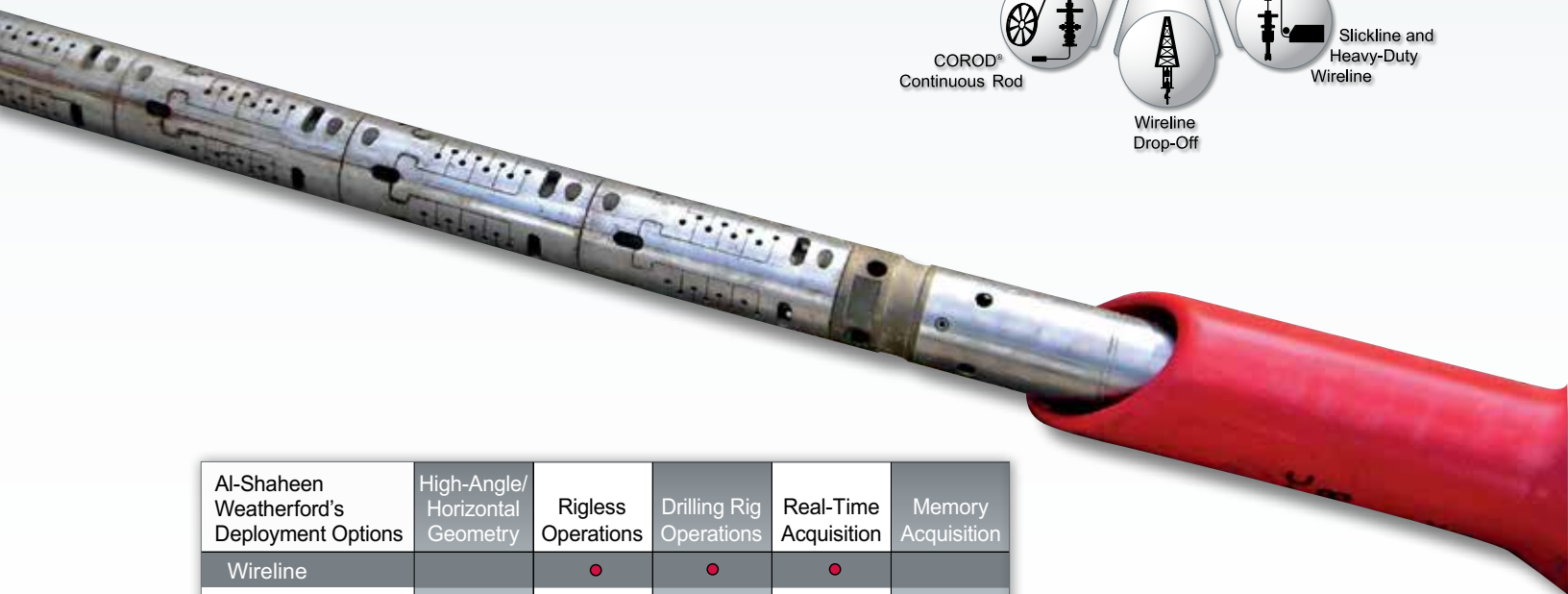
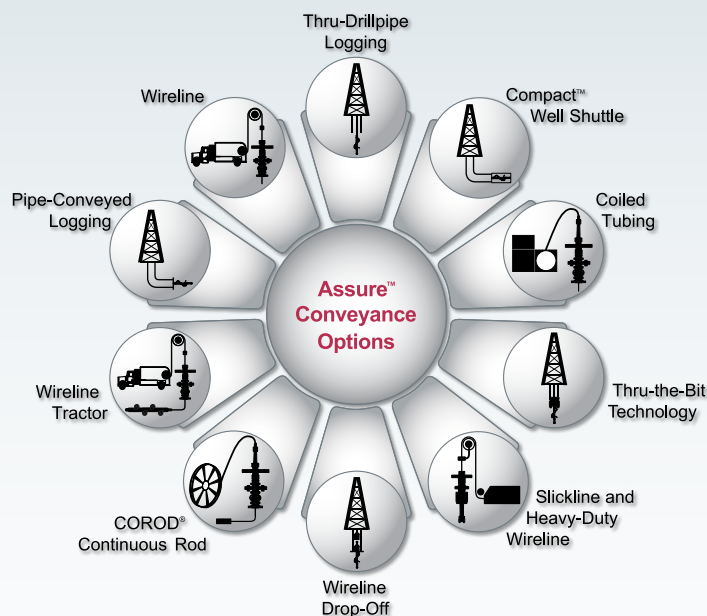
Patented isolator technology prevents direct flexural-wave transmission to the receivers through the tool body and provides a rugged tool for flexible conveyance. Anisotropy orientation data is produced by combining the CXD with either the *Compact* borehole navigation (MBN) tool or the CMI tool.



Assured conveyance options

With its unique profile and memory capability, the CXD tool is deployed by various methods—wireline, slickline, coiled tubing, thru-drillpipe, drop-off and well shuttle—inside the drillpipe. The design and conveyance flexibility of the tool facilitates access in vertical to highly deviated wells and challenging hole conditions without compromising borehole coverage and high-quality acoustic data.

Weatherford's *Assure* conveyance options offer a wide range of deployment techniques and measurements to design your data acquisition program with well-specific operational and economic requirements.



Al-Shaheen Weatherford's Deployment Options	High-Angle/ Horizontal Geometry	Rigless Operations	Drilling Rig Operations	Real-Time Acquisition	Memory Acquisition
Wireline		•	•	•	
Thru-Drillpipe	•		•	•	•
Well Shuttle	•		•		•
Coiled Tubing	•	•		•	•
Thru-the-Bit	•		•	•	•
Slickline		•	•		•
Drop-Off	•		•		•
Continuous Rod	•	•			•
Wireline Tractor	•	•	•	•	
Pipe-Conveyed	•		•	•	•

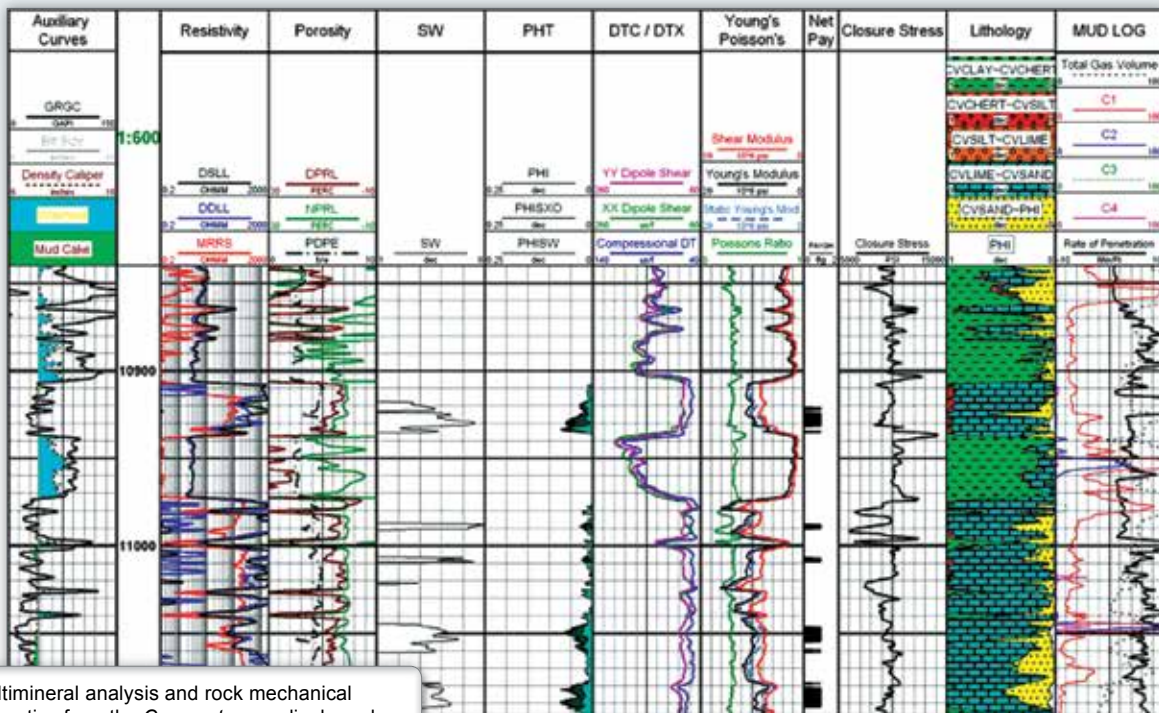


Assured Real Results

West Texas, USA

Compact cross-dipole sonic tool conveyed through drillpipe, provides valuable data in difficult openhole well

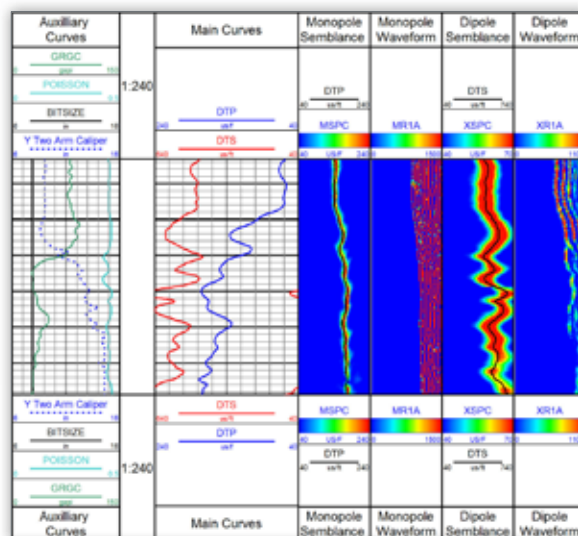
Weatherford's 2 1/4-in. diameter *Compact* triple-combo and CXD tools were used in a difficult openhole well in Texas to obtain high-quality log data. The use of *Compact* tools saved significant costs associated with wireline trips and enabled the operator to make quality decisions on the completion, based on the data analysis.



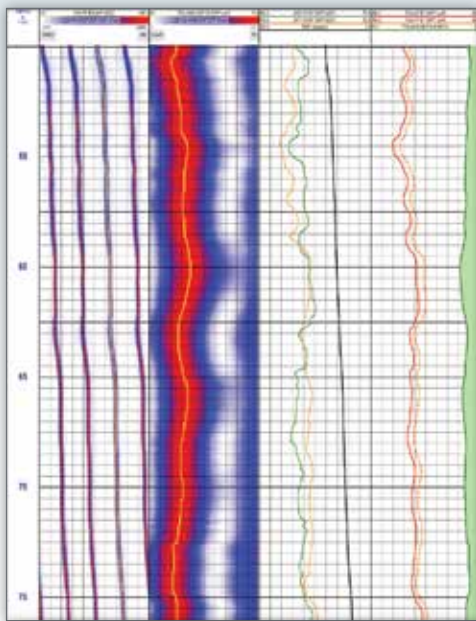
Multimineral analysis and rock mechanical properties from the *Compact* cross-dipole and triple-combo enabled a successful completion in a 11,300-ft (3,444-m) well in the Permian basin in west Texas, USA. The 2 1/4-in. *Compact* tools were run in the 7 7/8-in. hole where previous attempts to get to TD using standard wireline tools had failed. The operator saved at least 16 hr per round trip and significant costs.

Alberta, Canada

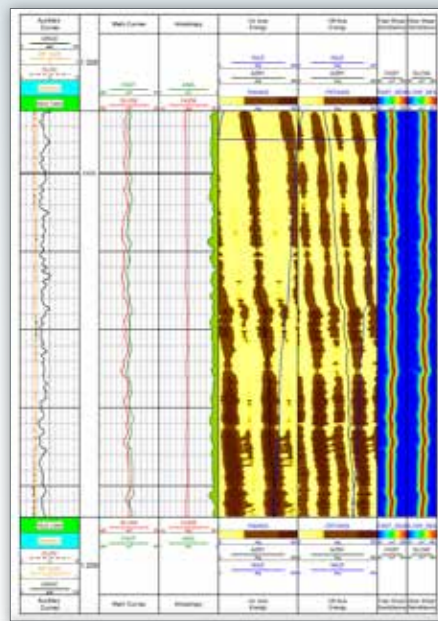
Crucial data often occurs in areas that are difficult to evaluate, such as unconsolidated or shallow sediments, washouts and surface boreholes. In this example the CXD shear slowness is reading 700 $\mu\text{s}/\text{ft}$ (2,300 $\mu\text{s}/\text{m}$), even though the hole is rugged and washed out to 15 in.



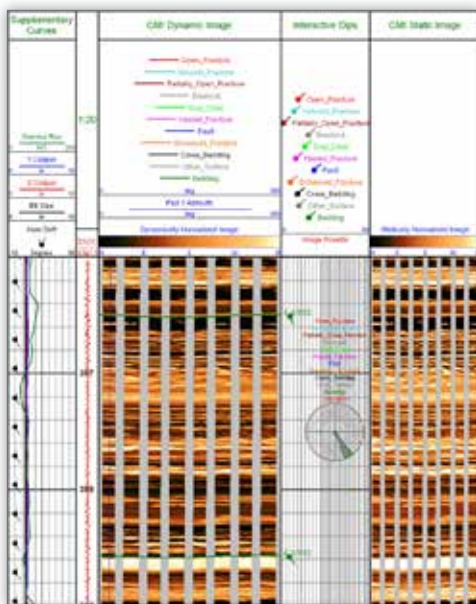
Assured anisotropy analysis



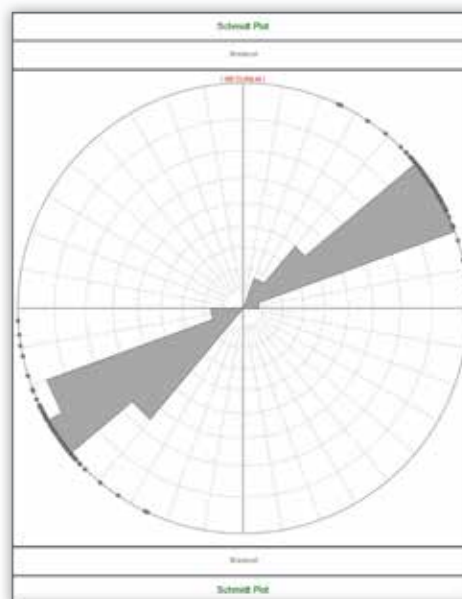
Cross-dipole anisotropy analysis is shown using perpendicular dipole measurements before and after alignment to maximum/minimum slowness orientation.



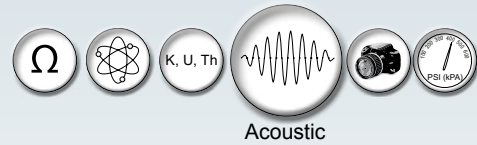
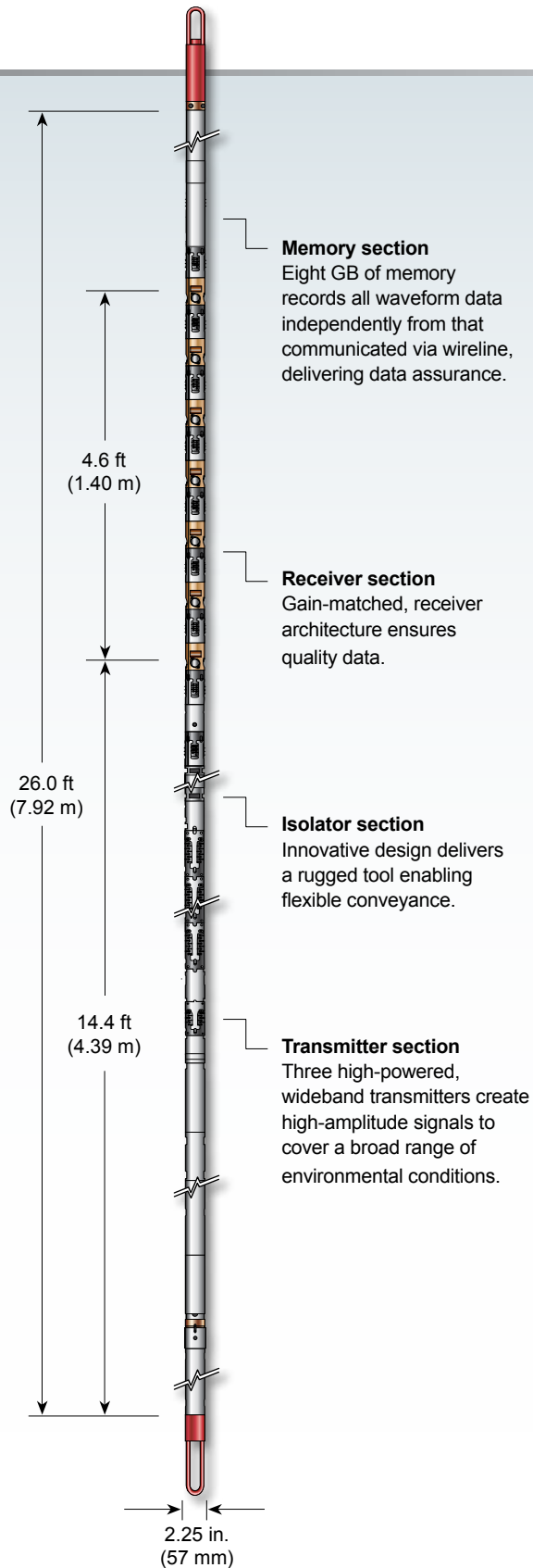
The Compact™ CXD and CMI tools were run for a U.K. operator to evaluate unconventional reservoir coal. Anisotropy analysis is shown in this log, using the fast- and slow-shear slowness with the fast-shear azimuth. The anisotropy is 10 percent, and the orientation of the maximum horizontal stress is 36° west of north. This analysis improved the formation characterization and indicated the intensity of natural fractures.



Breakout analysis from CMI log is consistent with the anisotropy analysis from the CXD.



CMI Schmidt plot shows breakout is consistent with the anisotropy analysis from the CXD.



Measurement Specifications

Data	Compressional (P-wave), shear (S-wave) slowness, fast shear azimuth
Logging speed	1,800 ft/hr (9 m/min)
Measurement range compressional slowness	40 to 250 $\mu\text{s}/\text{ft}$ (130 to 820 $\mu\text{s}/\text{m}$)
Measurement range shear slowness	70 to 700 $\mu\text{s}/\text{ft}$ (230 to 2,300 $\mu\text{s}/\text{m}$)
Vertical resolution	4.6 ft (1.4 m) Enhanced = 0.7 ft (0.2 m)
Accuracy	$\pm 2\%$
Depth of investigation	9 in. (229 mm)
Borehole fluids	WBM OBM Salt

Mechanical Specifications

Maximum outer diameter	2.25 in. (57 mm)
Length	26 ft (7.9 m)
Weight (in air)	239 lb (108.5 kg)
Maximum temperature	302°F (150°C)
Maximum pressure	15 kpsi (103 MPa)
Minimum borehole diameter	3.5 in. (89 mm)
Maximum borehole diameter	15.7 in. (400 mm)



Compact™ Cross-Dipole Sonic (CXD)

More options. More service.

Weatherford's *Compact* cross-dipole sonic (CXD) tool is part of a comprehensive portfolio of openhole and cased-hole wireline services, which provide Assure™ conveyance options and unequalled flexibility in choosing the right tactic to meet your operational and budgetary objectives. More options and more service are yours in terms of technology, conveyance, imaging and geosciences. To learn more, contact an authorized Weatherford representative, or visit **weatherford.com**.



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